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ABSTRACT

The James River is one of the most precious resources of Virginia. It was the site of the first permanent English settlement in the New World; the power of the water at the Fall Zone was a major factor in the development of Richmond; and the river served as a primary transportation route to the West via the Kanawha Canal. Both the water itself and the fish and shellfish it has produced have been used by humans for centuries. Management of the river is a complex problem involving ecological questions which are often influenced by both political and economic considerations. The activities in "River Times", a social studies program for students in grades 4 through 9, deal with both the geology and ecology of the James and the cultural history of the Capital region from the settling of Jamestown to the present. Students are introduced to the concept that environmental management is interdisciplinary in nature. Several of the activities encourage students to enlist the aid of their parents in answering questions or completing projects. The activity guide is based upon the following concepts: (1) the James River is a major geological feature in Virginia; (2) clean water is crucial to human, plant, and animal life; and (3) people's perceptions of the James River has changed over time. Black and white photographs, maps, drawings, reproductions of old prints and other graphics illustrate the text. (TW)

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RIVER TIMES

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RIVER TIMES is a science and social studies program for educators and students in grades four through nine, developed with a grant from the Virginia Environmental Endowment through Richmond Renaissance.

For information contact:
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Though the James is wholly contained within the state of Virginia, it is not a local river, for it belongs to the nation; not the native-born only, but also to those who have come from many lands to become citizens of the United States. So much of significance to our country has happened in the James River watershed that the river cannot belong to one state alone, but must belong to all.

Blair Niles, *The James: From Iron Gate to the Sea.*

INTRODUCTION

Dear Teacher,

This activity guide has been developed by the Mathematics and Science Center using a grant from Richmond Renaissance and the Virginia Environmental Endowment. The James River is one of the most precious resources of Virginia. It was the site of the first permanent English settlement in the New World; the power of the water at the Fall Zone was a major factor in the development of Richmond; and the river served as a primary transportation route to the West via the Kanawha Canal. Both the water itself and the fish and shellfish it has produced have been used by man for centuries. Thus the culture has been greatly influenced by the topography and by the ecology of the river. In return, man has had a significant impact upon the James. Early dams in Richmond and elsewhere prevented anadromous fish from traveling up river to spawn, causing their numbers to decline over the years. Cutting the forests and farming the land adjacent to the river have removed the natural vegetative protection, allowing rain to wash huge quantities of soil into the water. Farm and suburban fertilizers and sewage from treatment plants continue to wash into the river causing algae blooms and subsequent problems of eutrophication and reduced oxygen supply. The mid-1970's kepone contamination of the lower James was a major environmental disaster.

Since the pristine conditions of 350 years ago cannot be restored, this resource must be used wisely. Management of the river is a complex problem involving ecological questions which are often influenced by both political and economic considerations.

The activities in *RIVER TIMES* attempt to deal with both the geology and ecology of the James and the cultural history of the Capital region from the settling of Jamestown to the present. Students in grades 4–9 are introduced to the concept that environmental management is interdisciplinary in nature. It is hoped that they will see that such concerns impact all of us in one way or another.

Several of the activities encourage your students to enlist the aid of their parents in answering questions or completing projects. These activities are identified in the back of the book and can be used as you wish.

The teachers who conducted the research for this project and reviewers of the draft copies have all been impressed by the potential of materials which focus on the immediate environment to make history and ecology as concrete as possible for students. The James is a great resource which we must manage carefully to ensure its quality for future generations.

Teresa Auldridge, Project Director
August 1987

TABLE OF CONTENTS

Introduction 4
Credits 6
Concepts and Skills Outline 7
History of BELLE ISLE 8
James River Park Map 11

ACTIVITIES

Jamestown on the James 12
Fall Line City 14
Planters Advantages 18
Kanawha Canal 20
Flour Power 24
Row Your Boat 28
Iron and Industry 34
Plight of the Prisoner 37
A Tale of Two Cities 41
It's A Fact — or is it? 43
Divide and Conquer — The Story of a Watershed 44
The James Goes This Way 46
Rolling Down the River 48
Round and Round and Round it Goes 51
Critter Collecting — Everything in its Place 54
Crazy Critters 56
Belle's Profile 60
Make An Island 64
James Profile 66
Pothole Peeking 68
Save That Soil 70
Temperature and Dissolved Oxygen 72
Nutrients and Water Quality 75
Poison in the Food Chain 77
Toxic Troubles 80
Test the Water 82
Water We Doing to our Water? 83
Down the Drain 86
Information Pursuit 89
James River Gazette 94
Save the River Simulation 95
Grade Level and Subject Index 101
Parent Involvement List 101
Facts and Figures about James River 102
Glossary 103
Topic Index 108
Kit List 110
Acknowledgements and Picture Credits 111

FOLDOUT MAP:

Richmond Map — 1835
Plantation Map
Virginia Map
James River Through Richmond

SUPPLEMENTS:

Be Water Wise Booklet
Historic Landmarks Along the Lower James River Brochure
Getting Acquainted with Nature: Our Fresh Water Resources

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CONCEPTS AND PROCESS SKILLS

I. The James River is a major geological feature in Virginia.
a. Whether on the surface or underground, water continually moves from one place to another. (§ 9.9)
b. Water is connected to everything else in nature. (§ 4.14)
c. The river shapes and is shaped by the surrounding land. (§ 4.12, 9.9)

II. Clean water is crucial to human, plant, and animal life.
a. People have long used the James as a source of drinking water. (§§ 4.5, 4.6, 5.7)
b. Human activities affect water supplies and the organisms dependent upon them. (§ 4.14, 4.15; §§ 9.8)
c. Water is a renewable resource but wise water management is necessary to meet human needs. (§ 4.15; §§ 9.6, 9.8, 9.9)
d. Cost is a prime consideration in decisions regarding water.
e. Farming practices have a direct impact upon the quality of water.

III. People's perception of the James River has changed over time.
a. The river has been used as a source of food and water. (§§ 4.6, 5.7)
b. The river has been used as a transportation route and has also been seen as a barrier to travel. (§§ 4.6, 5.4, 5.7, 5.8, 9.8, 9.9)
c. The river has been used for industrial purposes such as grist mills, electric power generation, transportation of goods, etc. (§§ 4.6, 4.14, 5.7, 5.8, 5.10, 9.8)
d. The river has been used to dispose of wastes both municipal and industrial. (§ 4.15; §§ 5.10, 9.8, 9.10)
e. Floods have long affected human activity around the river. (§§ 5.7, 9.8, 9.11)
f. Belle Isle has been used for many different purposes.
g. The river has been used for recreation.

IV. Ecological concepts
a. Populations of plants and animals interact with one another and with their environment. (§ 4.14)
b. Living things progress through a cycle which includes death and decomposition. (§ 5.15)
c. Plants and animals have both structural and behaviorial adaptations which help them survive. (§ 5.16)

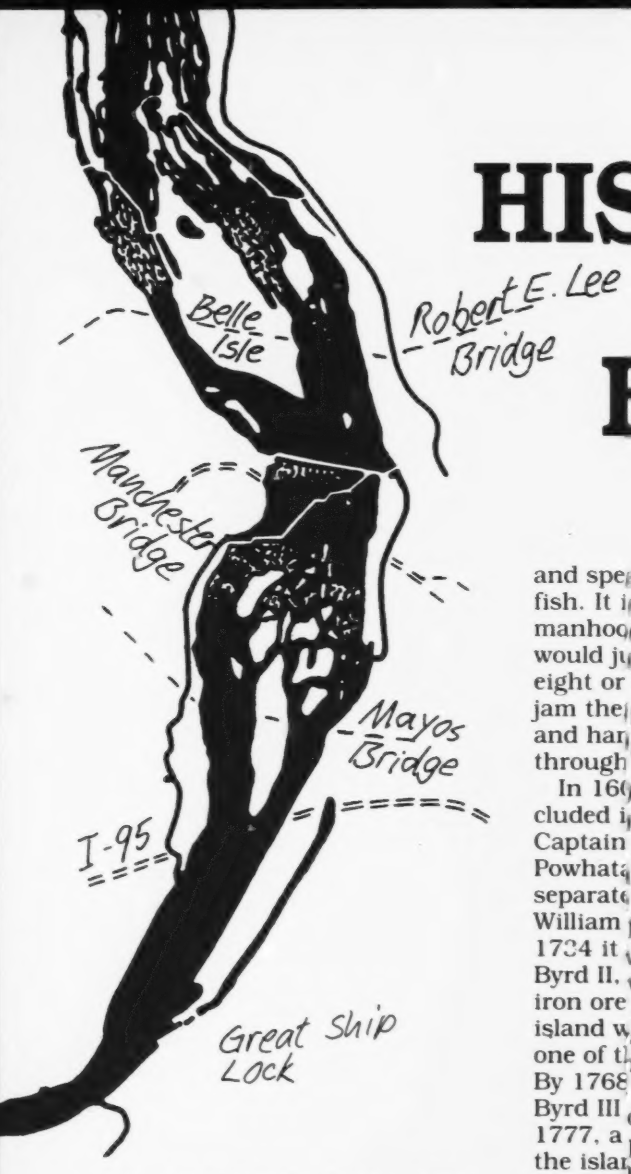
V. Skills
a. Mapping (§ 9.10; §§ 4.1, 4.2, 4.3, 5.1, 9.1, 9.2, 9.3)
b. Observing (§ 4.2)
c. Measuring (§ 4.6, 9.2)
d. Making inferences (§ 4.2; §§ 9.6)
e. Predicting (§ 4.5; §§ 9.6)
f. Questioning (§ 4.3, 5.2)
g. Gathering data (§ 4.3; §§ 9.6, 11.9)
h. Hypothesizing (§ 5.2; §§ 9.6)
i. Interpreting models (§ 5.4)
k. Experimenting (controlling variables) (§ 4.4, 5.3)

You will find a Roman numeral in the heading for each activity which indicates its correlation with one or more of these concepts.

§ indicates correlation with science SOL objectives.

§§ indicates correlation with social studies SOL objectives.

HISTORY OF BELLE ISLE



Belle Isle is located in the James River and is right in the heart of Richmond. The first known inhabitants were the Powhatan Indians. One 19th century source explains that it was supposedly

> *. . . a burial ground of the early Indians, but casual exploration of its interior has not justified so romantic a conclusion. . . . It is known, however, to have been occupied by aboriginal tribes many centuries ago, as their relics are found still in the lower alluvium of the island in the shape of broken pottery stone implements. . . . In prehistoric times it was probably a peninsula of the southside.*[1]

The Powhatans used the island for a seasonal fishing ground and would come annually to net, lasso, and spear sturgeon and other fish. It is said that as a rite of manhood, young Indian boys would jump on the back of an eight or nine foot long sturgeon, jam their hands into its gill slits, and hang on for an exciting ride through the rapids!

In 1608 "the island was included in the land purchased by Captain John Smith from Chief Powhatan . . . and was part of a separate Crown grant in 1636 to William Minefree or Winfree."[2] In 1724 it was owned by William Byrd II, who attempted to find iron ore on the site. To him, the island was known as Broad Rock, one of the first of its many names. By 1768 it was owned by William Byrd III of Westover. Around 1777, a private home was built on the island, one end of which was later used as a boarding house or hotel. The house remained fairly intact until a fire in the early 1980's, which destroyed all but the chimneys. When Byrd ran short of money, he held a lottery with Belle Isle advertised as the second prize. See the large map of 1835 for an illustration of the lots in Byrd's lottery. It was won by James Overton, who conveyed the island to Bushrod Washington, the nephew of George Washington, under whose ownership it was known as Washington's Island. Washington rented it to Benjamin Latrobe, who was enchanted by the beauty of the spot. In his journal, he describes it as follows:

> *On the south side of this Island the Channel is filled with immense Masses of Granite, among which the torrent roars with great impetuousity, dividing itself into a thousand separate streams, that wind their way through them tumbling in some places 4 or 5 feet perpendicularly, in other taking a course directly opposite to that of the river till met by some other that rushed again forward. An infinite number of small picturesque groups of rocks, trees and water, present themselves. On the North side several rocky islets, and innumerable broad and bare rocks produce the same effects but in a less degree. The largest Cascade, I have any where observed is at this place. The fall is about 6 feet, it is about 30 feet wide, and the depth at the edge of the fall about 5 feet. . . . The basis of Washington's Island is an immense Pile of Granite, abrupt and bare at the West end, but gradually sloping and covered in most places with Mould on every other side. Towards the East is a fruitful hanging plain of about 15 Acres; skirted round the edge with trees. The West end appears to have formerly withstood many a tremendous Attack from the Western Waters; huge fragments of rock that seem to have been violently torn from the Cliff cover its foot.*[3]

Latrobe purchased the island and planned to live there and farm the land. However, the city of Philadephia asked him to come north to design the city waterworks, and he left the island in the James. Eventually it was sold to Lighthorse Harry Lee, who conveyed it to Colonel J. Harvie (the J. stood for either John or Jacqueline). At this point existing reports conflict. It is known that Harvie had a farm on the island and bred horses there. He also ran a racetrack on the east end around 1827. Harvie later rented the island to James Bell, for

Old Dominion Iron and Nail Works on Belle Isle

whom the island was then named Bell's Island. Some sources say that Bell ran the racetrack rather than Harvie. Over the years the name was corrupted to Belle Isle and is today all that remains of the racetrack.

In 1815 a man named James Hume constructed a wooden dam on the south side of the island to provide power for a nail factory called Belle Isle Rolling, Milling, and Slitting Manufactory or Belle Isle Manufacturing Company. This company was one of the earliest industries in the city of Richmond, receiving its charter in 1832 and changing its name to Old Dominion Iron and Steel Works. Eventually it relocated to the eastern tip of the island. James Hume is also rumored to have begun a snuff factory on the island at about the same time the nail factory was built. Hume supposedly charged fishermen to come fish in the waters around the island.

In 1845 a larger, more permanent dam was built which channeled water to power the iron mill. About the same time a community of homes grew up on Oregon Hill in Richmond for the employees of the factory, but at one time many of them lived in a small community on the island itself. Serving the inhabitants were a church and a cemetery, probably located on the east end of the island.

Early bridges to Belle Isle included a railroad bridge from the south side, opened in 1854, and a span from Tredegar Iron Works on the north, opened in 1871.

By 1860, Old Dominion Iron and Steel Works was thriving. It produced from 75,000 to 80,000 kegs of nails a year, as compared to only 25,000 ten years before. In addition to making iron goods, the factory constructed its own kegs in a saw mill.

At this point there were 175 workers in the factory, with both whites and blacks making up the labor force. Slaves were rented out by their owners who needed the money the slaves could earn in the factory. In the beginning, the slaves worked as assistants to the English immigrant employees. Since their homes were usually too far away to return to each night, the slaves lived in ghettoes in Richmond.

Then came the Civil War and in 1862 Belle Isle was turned into a prison for Union enlisted men. The camp was a four acre plot of ground on the northeast end of the island. The men were crowded in with as many as 6,000 prisoners on the island at one time and over 20,000 total during the course of the war. During the summer months, the conditions were tolerable, with plenty of water for drinking and bathing—a luxury which the Union officers in Libby Prison on Church Hill did not have. However, in winter many prisoners died of exposure. Tents were their only shelter and frequently there were not enough of those. The Confederate Army had difficulty feeding its own soldiers, so food for prisoners was especially scarce. Many of them were forced to work in the iron factory on the island as a sort of slave labor.

The prison camp was very well protected, first by the rushing waters of the river, and second by guns on the hill of the island and on the south shore of the river. Also, there were trenches dug around the area of the camp, which served double duty as burial sites for prisoners who died. Unlike the present stand of trees on the island, photographs from the mid and late 1800's show the center of Belle Isle mostly cleared of trees, so sentries would have had an unobstructed view of the area. A small stone structure near the 1777 house, (which served as officers' quarters for Confederate

Quarry lake as seen today

guards), and a small pit on the top of the island were probably gun emplacements and ammunition storage areas. Both have thick walls banked with earth which would help guide an accidental explosion upward instead of out, reducing the chance of injury.

Two major Union cavalry raids, Kilpatrick's and Dahlgren's, attempted to liberate the prisoners but were unsuccessful. Many prisoners died of exposure and complications resulting from poor diet as almost no vegetables were available and scurvy was a major problem. In 1866 "Yankee" school teachers in Richmond held a memorial service for the Federal dead on the island, and several years later, the bodies were moved to a cemetery beyond Church Hill.

In the 1870's and 1880's the fortunes of Old Dominion Iron and Steel began to wane because rich iron ore was discovered farther west in Virginia. Eventually the mill began producing more specialized equipment, such as radiators, boilers, and other pressurized containers.

Around the turn of the 20th century, a quarry was started on the west end of the island which soon reduced the "immense pile of granite" described by Latrobe to a pit which is now filled with water. Granite from the quarry was cut and dressed for use as building foundations, and later became building blocks for the walls of the mill race which furnished water for a power plant on the south side of the island. By 1910 the quarry industry was in decline because granite was being replaced by concrete which was easier to cast and to transport.

The power plant mentioned above was constructed in 1914 by Virginia Electric and Power Company (now Virginia Power) and was located on the south side of the island near the site of the original iron mill. At the same time, Virginia Power built a bridge connecting the island with the north side of the river. The hydroelectric plant operated until 1965 and provided power for the Old Dominion Iron and Steel Works and sold surplus electricity to other iron mills and to the city.

In the early 1900's the city of Richmond thought of using the island for a jail, a sort of "mini-Alcatraz," but those plans never materialized.

In the mid 1950's a large neon sign advertising Climax Soft Drinks was erected on top of the island for the benefit of traffic on the Lee Bridge, which crosses the island.

In 1966, the city announced its intention to buy Belle Isle to use as a city park. Old Dominion Iron and Steel Works tried to stave off the impending sale by building three more large structures. Nature intervened, however, and the floods of 1969 and 1972 washed away the bridge and then the ferry which workers used to get to the island. Finally, Old Dominion agreed to sell and moved to a new location in Chesterfield County.

Belle Isle is now part of James River Park and is traversed by a new Lee Bridge, which parallels the original one.

[1] "A Visit to Belle Isle", *The State* (Richmond), February 15, 1877, p. 1.

[2] "New Owners Get Historic Local Concern," *Richmond News Leader*, March 23, 1945.

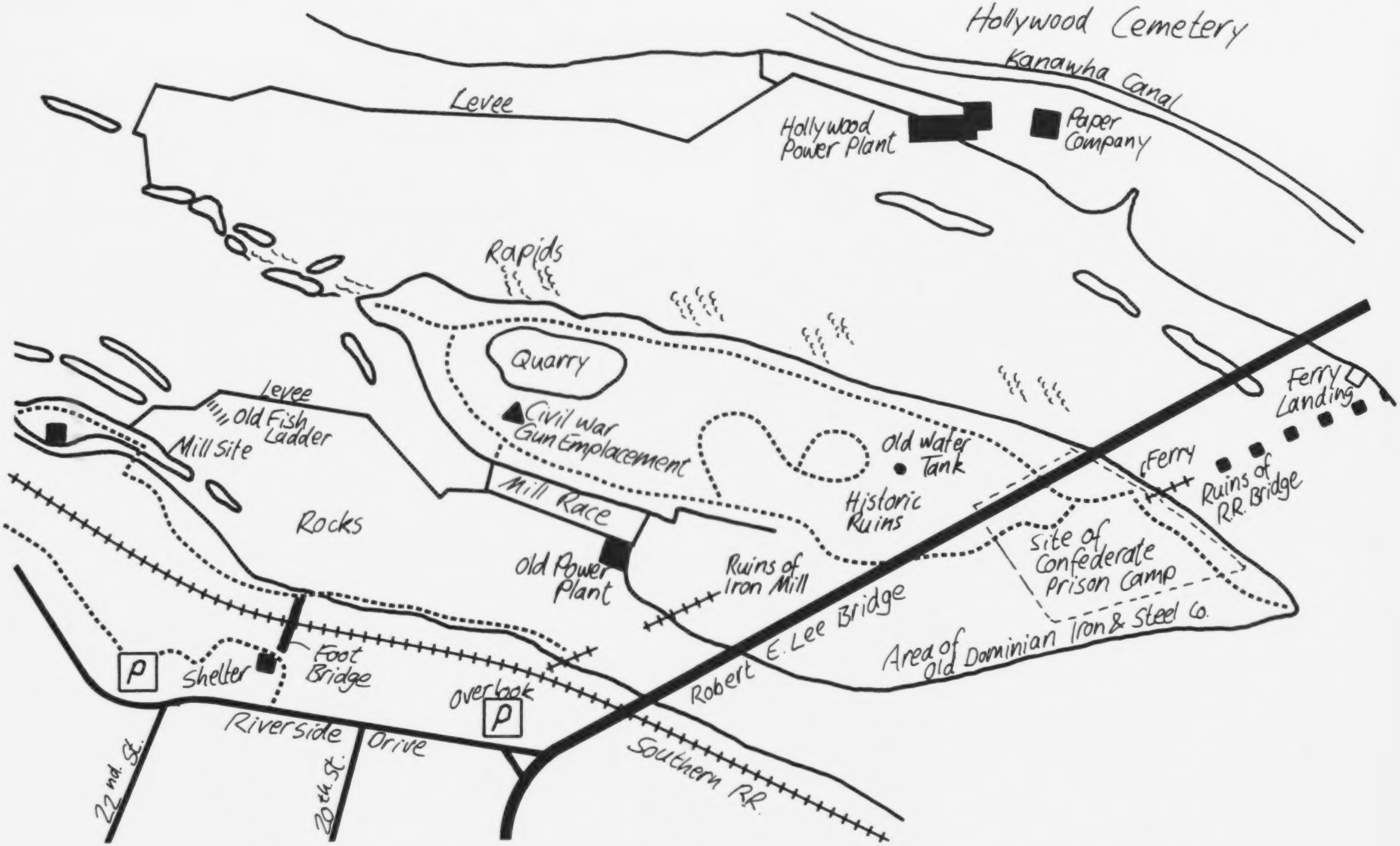
[3] Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985) pp. 113-114.

Other information taken from the above sources and from the following:

Elaine Lidholm, "Walking Guide to Belle Isle," second draft, March 9, 1985, volunteer, James River Park, Richmond.

Jeffrey Ruggles, Canal Walk Historic Marker Text, Richmond, Virginia, 1987.

David D. Ryan, *The Falls of the James* (The William Byrd Press, Inc. 1975) p. 36.


Hollywood Cemetery
Kanawha Canal
Levee
Hollywood Power Plant
Paper Company
Rapids
Quarry
Levee
Old Fish Ladder
Mill Site
Civil War Gun Emplacement
Old Water Tank
Ferry Landing
Ferry
Ruins of R.R. Bridge
Mill Race
Historic Ruins
Rocks
Site of Confederate Prison Camp
Old Power Plant
Ruins of Iron Mill
Robert E. Lee Bridge
Area of Old Dominian Iron & Steel Co.
P
Shelter
Foot Bridge
overlook
P
Riverside Drive
22nd. St.
20th. St.
Southern R.R.

JAMES RIVER PARK AT BELLE ISLE

Social Studies

SOL: 4.2, 4.3, 4.5, 4.10, 4.11, 5.7

IIa, IIb, IIIa, IIIb

Skills: interpreting maps, making inferences, determining cause and effect

JAMESTOWN ON THE JAMES

Objectives The student will (1) locate the site of the Jamestown colony on a map of the James River, (2) make inferences as to the quality of the drinking water in the river at that point, and (3) determine cause and effect relationships between the water supply and the sicknesses which plagued the colonists.

Methods Students will pretend they are Jamestown settlers and will keep a diary, write letters to loved ones in England, and/or dramatize the situation confronting the colonists with respect to the river, drinking water, and illness.

Background On December 20, 1606, Captain Christopher Newport left London with three ships, the *Susan Constant*, the *Godspeed*, and the *Discovery* and set sail for Virginia. In May of 1607 they entered the mouth of the Chesapeake Bay and traveled up the river which they named the James (after the King) hoping to find the road to wealth. Thirty miles upstream they found a low-lying peninsula about two miles long and one mile wide, linked to the mainland by a narrow sand bar. On one side was a deep river channel and on the other was Back River, a deep marsh creek which could shelter ships.

Though the English were delighted to have found a place of easy anchor and defense, there were many other conditions they failed to consider. The fact that there were no Indians residing on the land that May morning should have been a clue.

This island, which the settlers promptly named for their king, was probably the worst piece of real estate on the river in the summer time, and the Indians knew it. It lay very low, invaded by stagnant swamps, and it had no freshwater springs. Salt water mixed with fresh water in the summer at that point of the river to create what is now called a "zone of maximum turbidity." This meant that the river was often turgid and brackish at low water, not at all suitable for drinking . . . Defense and navigation, not the quality of the water they had no intention of drinking, were the prime considerations.

It is not difficult to understand why the Indians, poised for attack, put away their weapons and generally left the white men alone. We have their own words for the reason . . . Their leader reassured them . . . saying, "Why should you be offended with them as long as they hurt you not, nor take any thing away by force. They take but a little waste ground which doth you nor any of us any good."[1]

Eventually, of course, the beer the colonists brought with them ran out and they had to resort to drinking river water. Unable and unwilling to change their diet and search for food as the Indians did, the settlers began dying from a combination of starvation and disease. The latter was particularly prevalent in the summer months when a wedge of salt water moves up from the Bay to the Jamestown area. Sewage from the colony was washed into the river and the relatively sluggish water did not carry it away. Many out of each new group of colonists died before they had a chance to adjust to the conditions. The high salt content of the water in the summer may have "literally poisoned the men, making them too lethargic even to dig a well for fresh water."[2]

Another health hazard was the malaria, spread by mosquitoes which bred in the marshes around Jamestown. By 1624, of the 5,000 people who had come to Virginia, only about 1,000 remained. At least half of those who died succumbed to water related diseases at Jamestown.[3]

More information about Jamestown and the first settlers can be found in the *Virginia History and Geography* text (Silver Burdett Company, 1985).

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[1] Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985), p. 36.

[2] Ibid. p. 39.

[3] Ibid. p. 40.

Procedure Before introducing the students to the situation the colonists encountered at Jamestown, have them make a list of what they would look for in a place to settle if they had been a member of Captain Newport's group. Encourage them to consider their physical needs for food, water, and shelter as well as safety from the Indians whose territory they were invading.

Show the students the map of the Jamestown site and ask them to guess why the colonists decided to stop there.

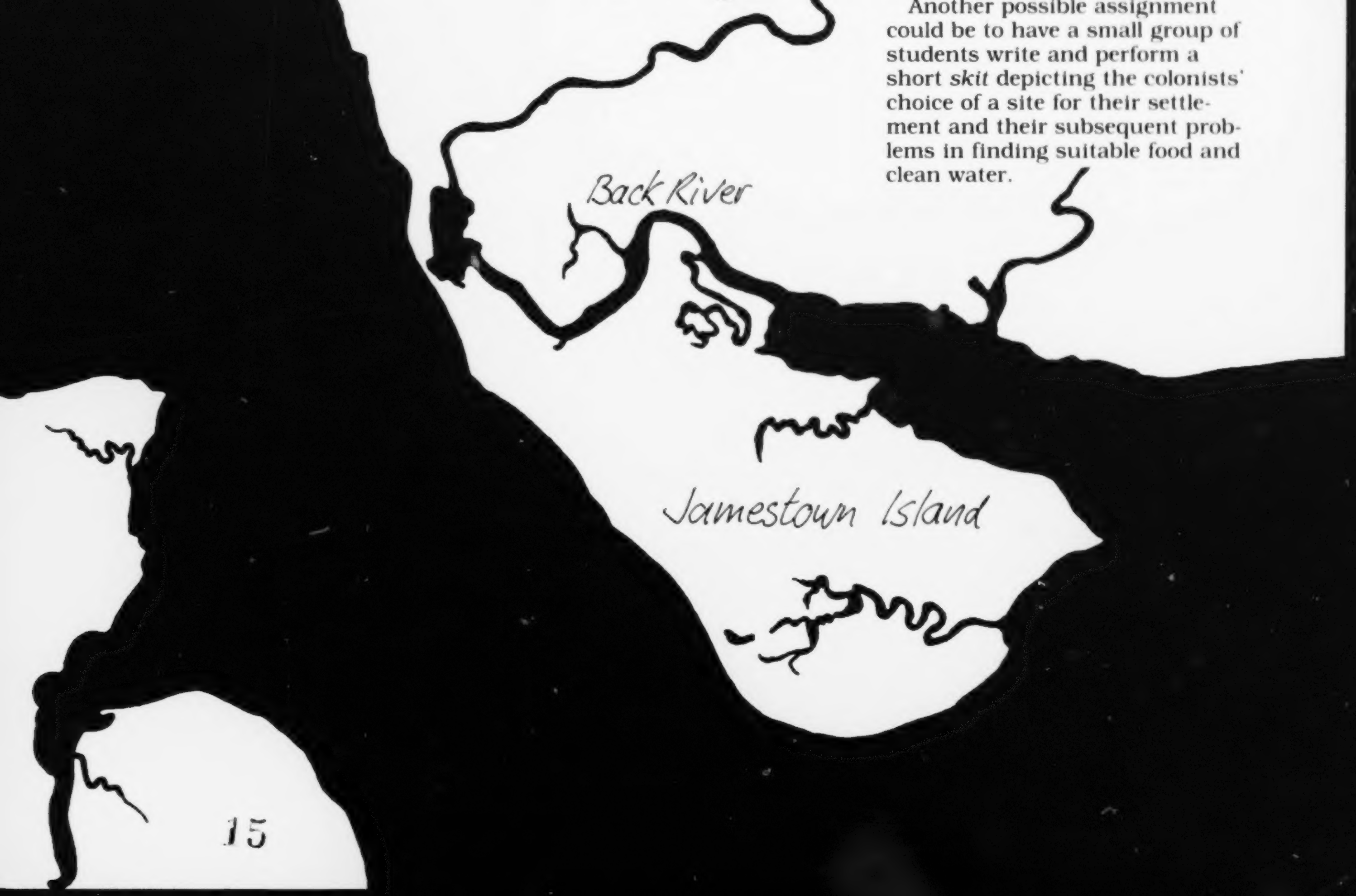
Next point out how close Jamestown is to the Chesapeake Bay and discuss the fact that the water in the tidewater portions of Virginia's coastal rivers is always brackish or salty. Explain that there is usually little rainfall in the late summer, which means that there is less water in the river and the tides bring in even more salt water than during the rest of the year. Obviously there were no sewage treatment facilities at Jamestown, so waste from the colony was washed into the river as well, making it even more unfit to drink than it is naturally.

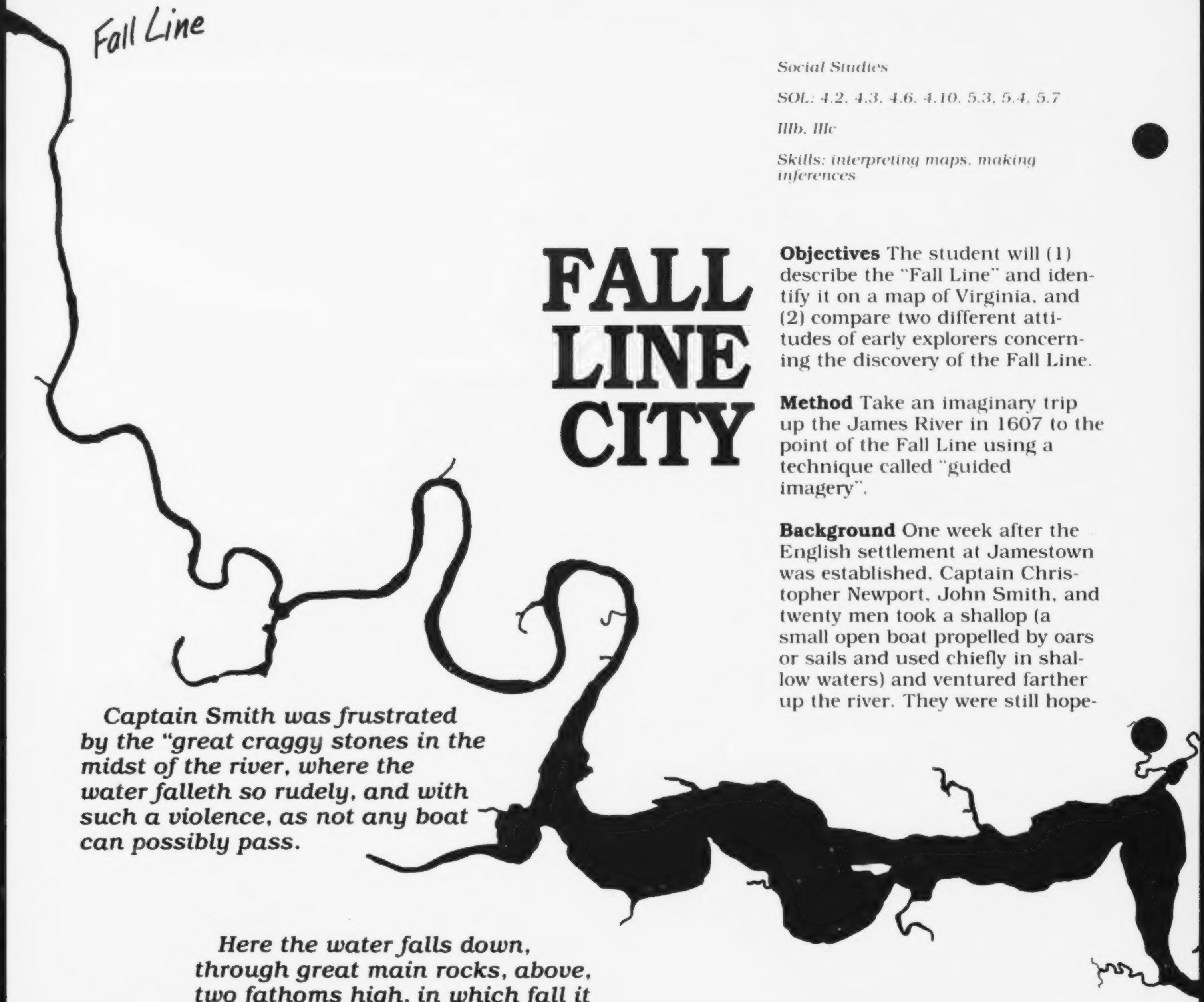
Discuss the fact that the colonists were reluctant to learn how the Indians gathered food and water and ask why they might have felt that way. (They considered the Indians to be savages and heathens and therefore not worthy of emulation in any area.) What were the consequences of their stubbornness? Since the Indians pretty much left them alone, what are some possible reasons so many of them died? Also ask the students to guess why the Indians didn't attack the colonists.

Have the students do one or more of the following activities.

Ask the students to pretend that they were some of those first settlers at Jamestown. Have them keep a *diary* of their experiences from May 1607 to May 1609 (assume they were one of the lucky ones who lived that long!) and make entries for each season of the two year period. An alternative would be to write *letters* to loved ones in England telling of their experiences in the New World.

Another possible assignment could be to have a small group of students write and perform a short *skit* depicting the colonists' choice of a site for their settlement and their subsequent problems in finding suitable food and clean water.





Social Studies

SOL: 4.2, 4.3, 4.6, 4.10, 5.3, 5.4, 5.7

IIIb, IIIc

Skills: interpreting maps, making inferences

FALL LINE CITY

Objectives The student will (1) describe the "Fall Line" and identify it on a map of Virginia, and (2) compare two different attitudes of early explorers concerning the discovery of the Fall Line.

Method Take an imaginary trip up the James River in 1607 to the point of the Fall Line using a technique called "guided imagery".

Background One week after the English settlement at Jamestown was established, Captain Christopher Newport, John Smith, and twenty men took a shallop (a small open boat propelled by oars or sails and used chiefly in shallow waters) and ventured farther up the river. They were still hopeful of finding the "Northwest Passage" to the "South Sea" where gold and other riches were supposedly waiting to be claimed.

On May 21, 1607, the party came to the Fall Line or more accurately, the Fall Zone. This is an area which can be found on any of the tidal rivers along the east coast. It occurs where a river flows over a series of rapids and falls as it moves from the harder rock of the Piedmont Region to the softer sediments of the Atlantic Coastal Plain. In Richmond the Fall Line is a stretch of approximately seven miles over which the elevation of the river drops 105 feet.

Captain Smith was frustrated by the "great craggy stones in the midst of the river, where the water falleth so rudely, and with such a violence, as not any boat can possibly pass.

Here the water falls down, through great main rocks, above, two fathoms high, in which fall it maketh divers little islets, on which might be placed a hundred water-mills for any uses.

James River
Jamestown

Captain Smith was frustrated by the "great craggy stones in the midst of the river, where the water falleth so rudely, and with such a violence, as not any boat can possibly pass."[1]

Another member of the party, George Percy, described the discovery in a slightly different way:

> *Rowing some three miles in shoal water, we came to see an overfall, impassable for boats any further. Here the water falls down, through great main rocks, above, two fathoms high, in which fall it maketh divers little islets, on which might be placed a hundred water-mills for any uses. Our main river ebbs and flows four feet, even to the skirt of this downfall. Ships of two hundred or three hundred tons may come to within five miles thereof, and the rest deep enough for barges or small vessels that draw not above six feet of water.*[2]

Obviously "beauty is in the eye of the beholder" and also depends upon the hopes and expectations of the explorer.

Before leaving the Falls, the party set up a cross and named the river the James for the King of England, thus claiming it for the English.

As it turned out, of course, the fabled South Sea (or the Pacific Ocean) was considerably farther away than the early explorers had hoped. Thus, Mr. Percy's attitude toward the Falls was much more insightful than that of Captain Smith. Since larger ships could not travel beyond the Fall Line, towns were quickly established at this spot on each of the major rivers of Virginia. Alexandria grew up on the Potomac River, Fredericksburg on the Rappahannock, Richmond on the James, and Petersburg on the Appomattox.

Since roads were few and travel overland was extremely difficult, the rivers were the highways of the time. The Fall Line towns became transportation centers where goods were unloaded from oceangoing ships and taken farther inland by other means. They also became places where tobacco was stored in warehouses before it was shipped downriver for export. Many kinds of mills, which used the falling water for power, were built along the rivers creating more commerce for the Fall Line cities.

Over the years, seven sites in downtown Richmond have been locations for a variety of water-powered industries:

HOLLYWOOD: A flour mill was operating by 1800. Canal water powered a paper mill beginning in 1887, and a 2,100 kilowatt hydroelectric plant from 1940 to 1972. River water powered a city hydroelectric plant until 1986.

TREDEGAR: Canal water powered a flour mill by 1801, the Armory by 1802, and Tredegar Iron Works beginning in 1837.

BASIN RACE: Basin water supplied a mill race which powered a paper mill beginning in 1834.

GALLEGO MILLS: Basin water powered flour mills beginning in 1834.

HAXALL MILLS: River water powered Ross's Mill by 1788. Haxall Canal water supplied power for flour mills from 1809 to 1894, and an 8,800 kilowatt hydroelectric plant from 1901 to 1968.

BELLE ISLE: River water powered an iron works by 1848, and filled a basin which ran a 3,000 kilowatt hydroelectric plant from 1914 to 1965.

MANCHESTER: Manchester Mill Canal was open by 1804, and powered a series of mills: in 1895 it supplied two paper mills, a corn mill, and a flour mill; and from 1925 to 1965 it fed a 1,000 kilowatt hydroelectric plant.[3]

See the activities entitled FLOUR POWER, IRON AND INDUSTRY, KANAWHA CANAL, and the HISTORY OF BELLE ISLE for more information about the development of river based industry.

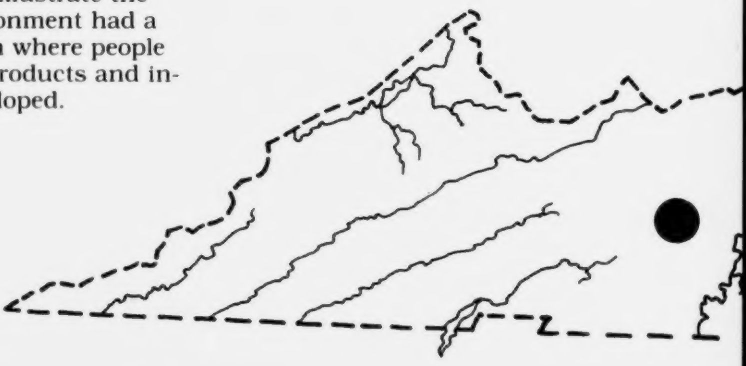
These examples illustrate the fact that the environment had a direct impact upon where people settled and what products and industries were developed.

Procedure Before discussing the attitudes of the English explorers who first saw the falls of the James, have the students participate in the following "Guided Imagery" or visualization exercise. Brain researchers and learning theorists say that this technique facilitates long-term memory and comprehension of concepts by stimulating the right hemisphere of the brain.

Give the students the following directions:

You are to try to imagine the things you will hear me describe. I won't put in all the details — so you must try to see and feel the scenes for yourself. I want you to imagine that you are a member of Captain Christopher Newport and Captain John Smith's party setting out from Jamestown to explore farther up the James River in May 1607.

Get yourselves in a comfortable place. Don't worry about who is sitting next to you. All of you will have your eyes closed. Just be comfortable, and do your best to imagine the things I will describe. Okay, close your eyes, and use your imagination . . . It is early morning on a late spring day . . . There is a coolness in the air . . . You and 21 other settlers are get-



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[1] Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985) p. 38.

[2] David D. Ryan, *The Falls of the James* (The William Byrd Press, Inc., 1975) p. 40.

[3] Jeffrey Ruggles, Canal Walk Historic Marker Text, Richmond, Virginia, 1987.

ting into a small boat tied up beside the new settlement at Jamestown . . . The river is very wide and flows slowly along in the early morning mist . . . You row upstream for many miles . . . The only breaks in the trees along the banks are where smaller rivers and streams flow into the great river you are on . . . You travel for a long time and finally notice that the river is much shallower . . . After rowing a few more miles you begin to hear the sound of falling water . . . The sound gradually gets louder and louder . . . Finally you have to stop rowing your boat because you can't go any farther . . . Everyone in the party stares at the river . . . The water is tumbling down over rocks and smashing into boulders for as far upstream as you can see . . . The river is not as wide as it was where you began, but there are rocks and islands and white water from bank to bank . . . Your journey up river is at an end . . . You must turn around and go back to Jamestown.

Wait a few seconds and then tell the students to open their eyes.

Ask the students to volunteer to share the scenes and feelings they had on their imaginary journey. Try to find out if any of them were discouraged to run into the Falls and not be able to go any farther. Ask if others saw any opportunity in the tumbling water. Share the stories of the two different descriptions of the Falls found in the Background section above. Ask the students why they think Captain Smith and Mr. Percy each felt as he did about the Falls.

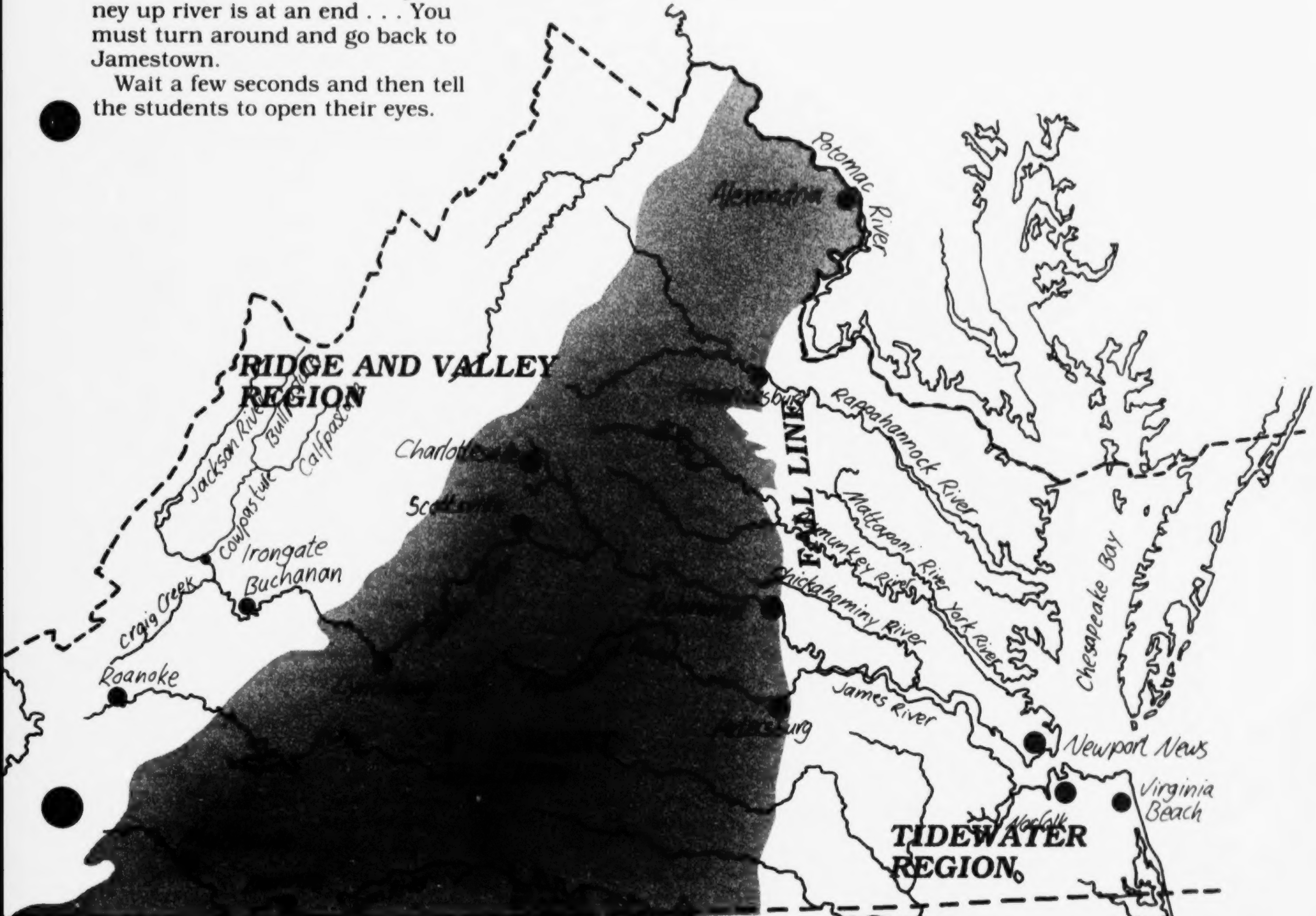
Have the students look at the map of Virginia and identify the cities and rivers along the Fall Line. Ask them to describe some of the possible reasons that these cities grew up in these locations. To what extent did Mr. Percy's vision come true?

Is it still important for cities to be located on rivers? (Some still use rivers for transportation of goods and many use rivers as a source of water and/or waste disposal.) Is it *as* important as it was in the past? Compare the ways rivers were used in the past with the ways we use them today.

What other means of transportation and power generation do we have now that the early settlers did not have?

What other environmental factors influenced development and expansion in America? (Mountains, suitability of land for crops, natural resources such as coal, oil, iron ore, etc.)

Activity adapted from "Stormy Weather," *Project WILD* (Western Regional Environmental Education Council, 1983) p. 25. Contact the Virginia Commission of Game and Inland Fisheries, 4010 West Broad Street, Richmond, VA 23230, 804-257-1000 for more information about Project WILD.


RIDGE AND VALLEY REGION
Jackson River
Bullpasture
Calfpasture
Cowpasture
Irongate
Buchanan
Craig Creek
Roanoke
Charlottesville
Scottsville
Fredericksburg
Alexandria
Potomac River
Rappahannock River
FALL LINE
Mattaponi River
Pamunkey River
Chickahominy River
York River
Richmond
James River
Petersburg
Chesapeake Bay
Newport News
Norfolk
Virginia Beach
TIDEWATER REGION

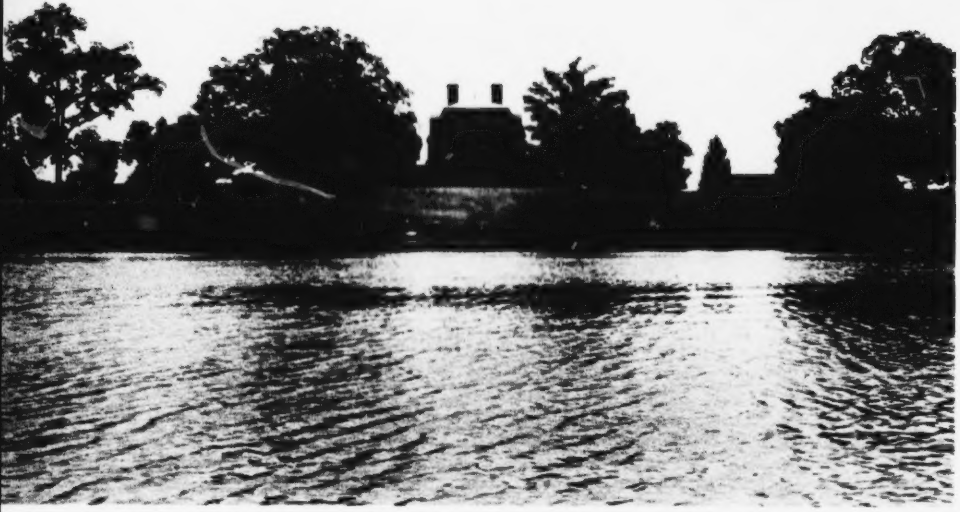
Social Studies

SOL: 4.3, 4.6, 4.7, 5.3, 5.7

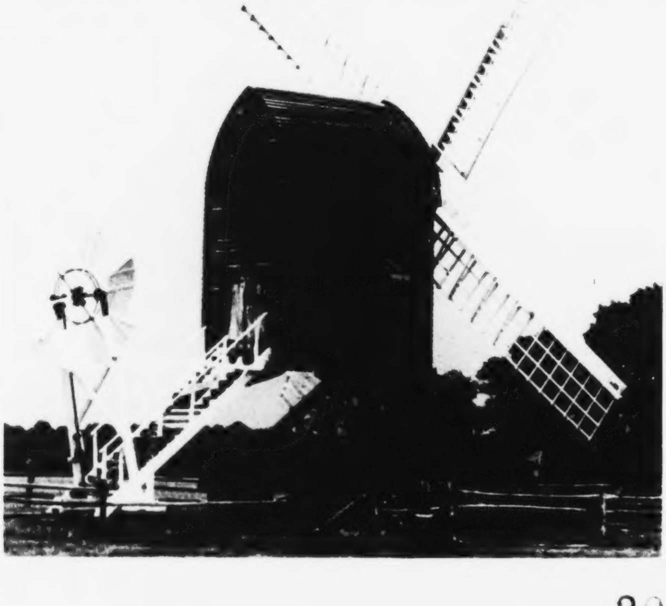
IIIb, IIIc

Skills: interpreting maps, making inferences, interpreting models

PLANTERS ADVANTAGES



Shirley Plantation



Windmill at Flowerdew Hundred

Objectives The student will (1) explain why many large plantations in colonial Virginia were located along rivers, and (2) identify the location of some of the larger plantations on a map of the lower James River.

Method Students will use a map of the lower James to see where some plantations can be found, research the history of some of the plantations, and/or draw a map or construct a model of a river plantation.

Background Gradually some of the early settlers in the New World began securing large tracts of land stretching along the fertile soils close to the rivers. The larger farms were called plantations and their owners were "planters." Often there was only one main crop on these tracts, the most important of which was tobacco.

Most plantations were built along the tidewater portions of the rivers so that the tobacco and other crops could easily be loaded on ships and taken to England to be sold. The ships later returned from England with goods such as cloth and furniture, using the rivers as the highways of the day.

Since this highway was sometimes unpredictable (either too much water or too little for large ships to travel safely), planters had to have a wide variety of craftsmen in their service and the plantations became fairly self-sufficient. The manor house was usually built so that it overlooked the river and could take advantage of the cool breezes that came off the river in the summer time. The illustration accompanying this activity shows the location and variety of the various buildings and the wharves on a typical James River plantation. (Also see p. 135 in the *Virginia History and Geography* text, Silver Burdett Company, 1985, for a drawing of

Scientists carefully uncover artifacts and look for other signs of previous human activity at the site of an archaeological dig such as this one at Flowerdew Hundred Plantation.

a river plantation with a ship in the foreground.)

One of the wealthy planters in early Virginia was William Byrd II who had inherited 25,000 acres along the James River from his father and grandfather. He was the builder of Westover Plantation and he wrote a book called the *Natural History of Virginia*. This book gives testimony to the fact that the river was crucial to the lives of the early Virginians and greatly contributed to the wealth of those with access to it.

Farther back from the rivers were the small farmers who were generally denied access to the water by the 1800's. Their crops had to be sold through the nearest plantation owner with a wharf. "Many of the more enterprising farmers, especially south of the river, eventually gave up and went to North Carolina to be free of the power of the river barons."[1]

The plantations along the James River were the site of several famous historical events. For example, Berkeley was where Virginia's first Thanksgiving was held and is the birthplace of both Benjamin Harrison V, signer of the Declaration of Independence, and his son, William Henry Harrison, ninth president of the United States. Carter's Grove is on the location of an early settlement called Martin's Hundred which was wiped out by the Indian massacre of 1622. Flowerdew Hundred is the site of America's first windmill and was one of only seven settlements to *survive* the Indian massacre of 1622.

Procedure Read the information in your social studies text regarding plantations in early Virginia and discuss the additional information provided above. Ask the students to list some possible reasons for plantations being built along rivers.

Have the students do one or more of the following activities:

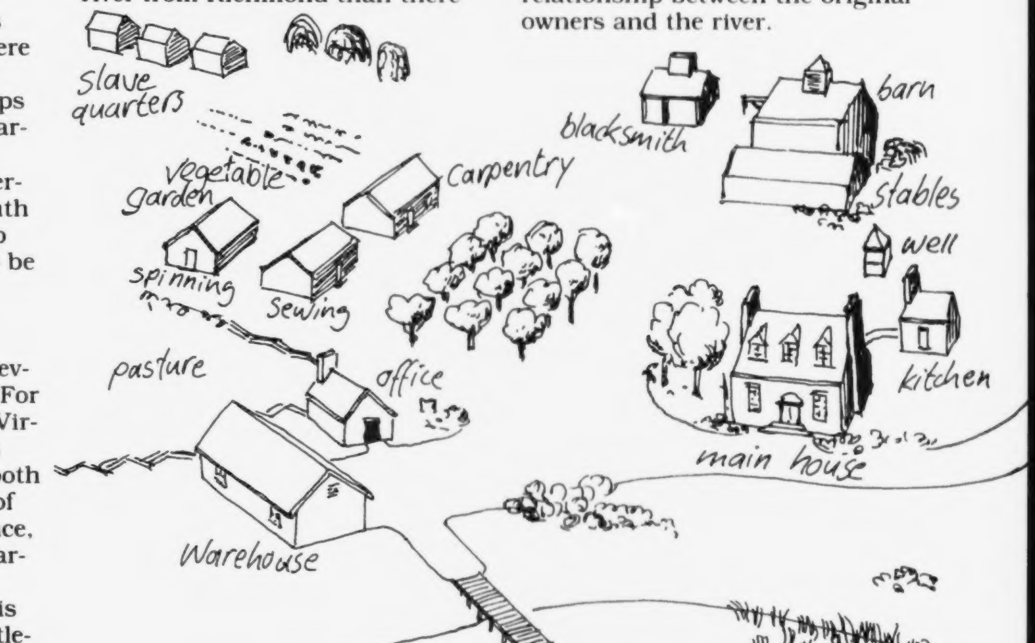
Use the brochure entitled "Historic Landmarks Along the Lower James River" found in this guide to locate some of the larger plantations along the James River. Why are there many more downriver from Richmond than there are upriver? (The Fall Line prevented navigation beyond that area and the advantage of using the river to export and import was drastically reduced.)

Have students find out when some of these plantations were constructed and by whom. Identify historical events associated with some of the plantations.

Have students draw a map or construct a model of a river plantation. Tell them to keep in mind the disadvantages (floods) as well as the advantages (transportation, cool breezes in summer, fertile soil on the flood plain) of life next to the river and to design their plantation accordingly.

Extra copies of the brochure mentioned above can be obtained from The Lower James River Association, P.O. Box 110, Richmond, Virginia 23201, (804) 730-2898.

Extension If possible, take a field trip to a James River plantation and ask the guide to focus on the relationship between the original owners and the river.



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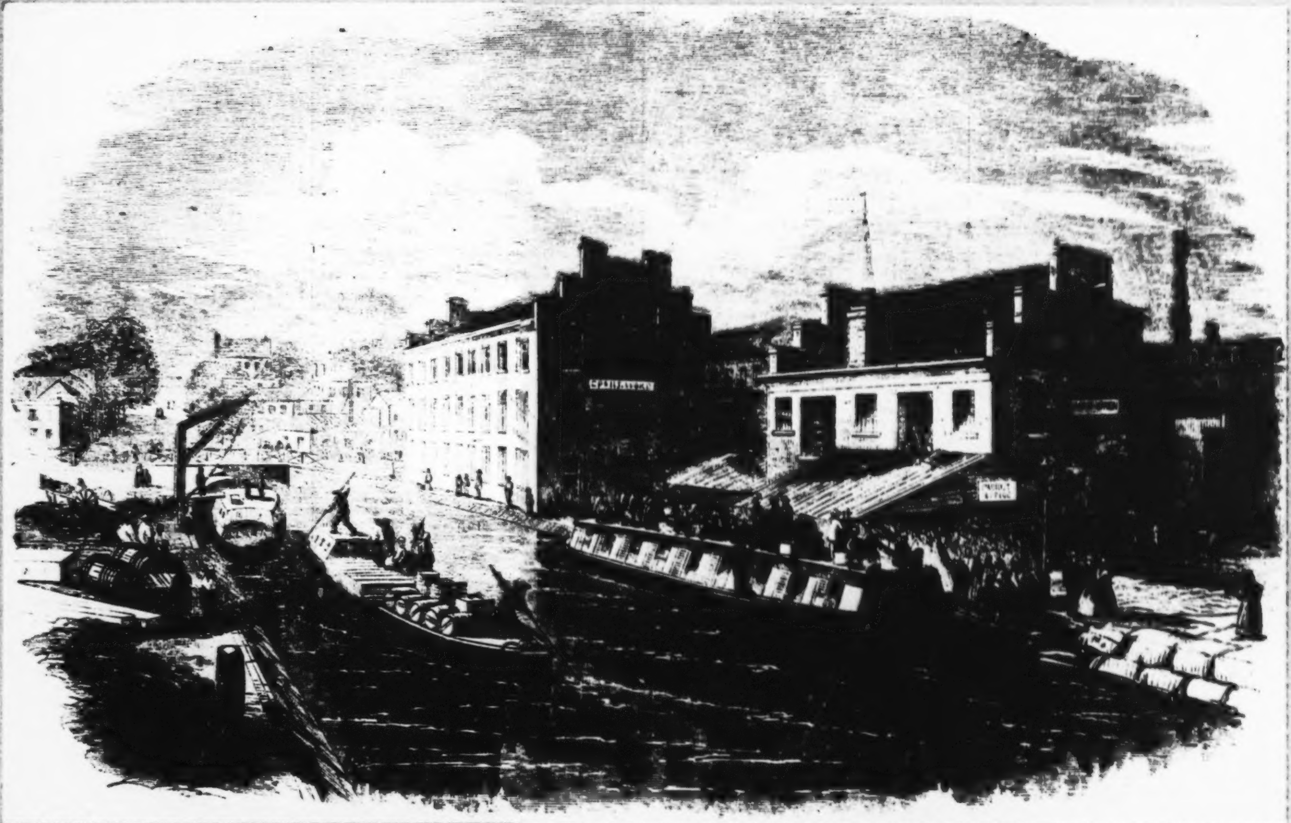
[1] Ann Woodlief, *In River Time: The Way of the James*, (Algonquin Books of Chapel Hill, 1985) p. 71.



KANAWHA CANAL

Social Studies

SOL: 4.3, 4.7, 4.14, 5.3, 5.4, 5.7, 9.8, 9.9, 9.11

IIIb, IIIc, IIIe

Skills: mapping, interpreting models

Objectives The student will describe the reasons for both the construction and the demise of the James River and Kanawha Canal.

Method Students will draw a mural of the James River and Kanawha Canal across Virginia, draw or construct a model of a set of canal locks, and/or write a diary as if they were workers helping to construct the canal.

Background One of the greatest feats of human labor in recent history began as simply a way to enable boats to get around the Falls of the James and navigate on up the river. In 1774 George Washington proposed the building of canals around the falls of both the James and the Potomac Rivers. It soon became Washington's dream, however, to construct "The Great Central American Water Line" with canals and highways from the James to the Kanawha, Ohio, Mississippi, and Kansas Rivers, eventually connecting the Atlantic Ocean with the Rocky Mountains. The rapidly emerging western frontier with all of its crops, coal, lumber and other goods was the main impetus for the project.

In 1785 the James River Company incorporated and elected George Washington as its first president. Within 10 years the company had built two canals around sections of the Falls in Richmond. By 1800 the Great Basin was completed and was a block wide and three blocks long. Its docks became the eastern terminus of the route to the west. Full tolls were levied in 1806 and freight was carried on various types of boats from Lynchburg to Richmond.

Citizens complained, however, that the company was more interested in profits than in making necessary improvements and repairs to the canal, so the state purchased the charter in 1820. However, the state was not much more successful in keeping people happy and ended up selling the canal to the James River and Kanawha Canal Company in 1835. That company grew to become one of the largest ante-bellum corporations in America.

Pungee schooner
on Kanawha Canal

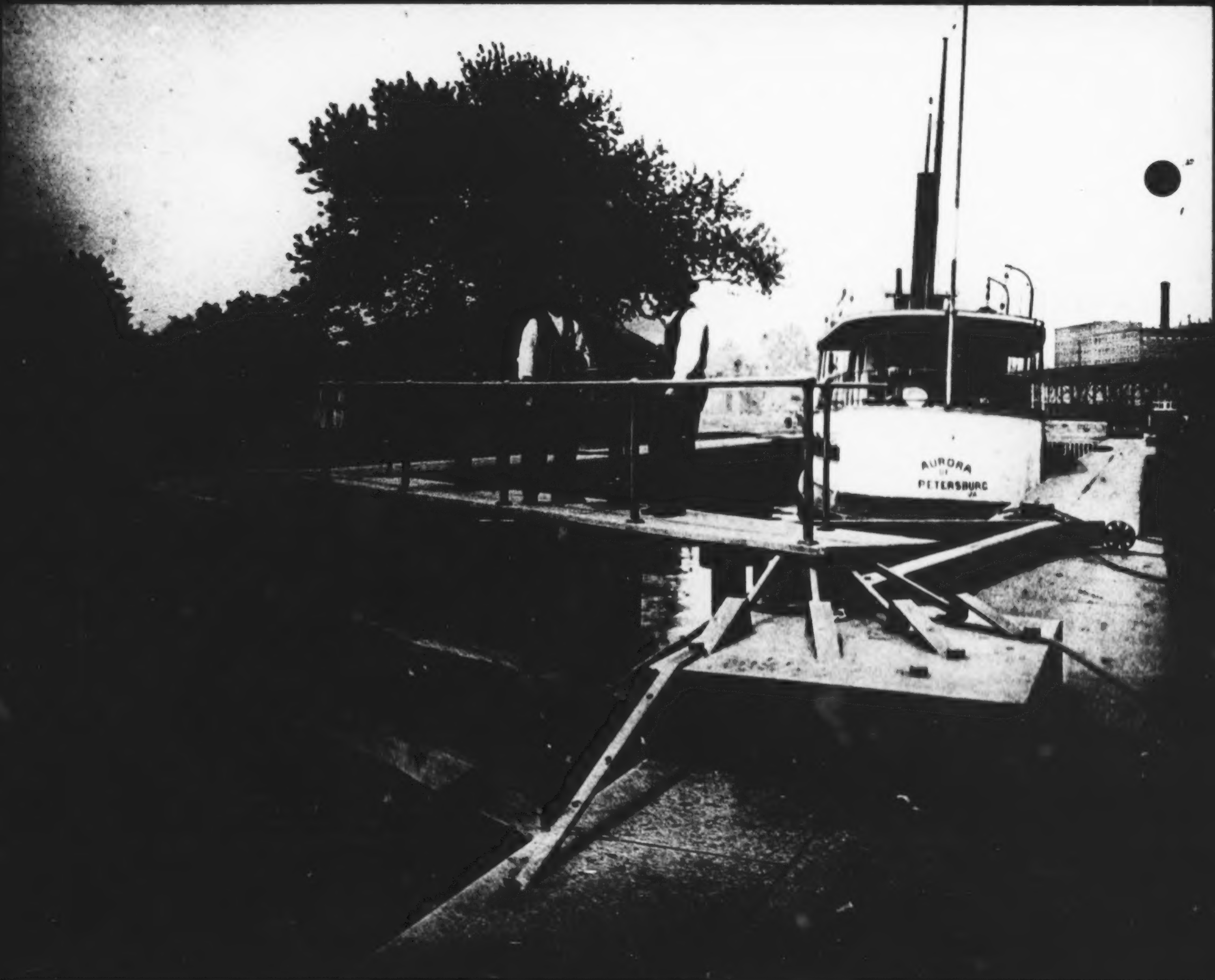
In 1837, 3300 workers were employed on the project. It was completed as far as Lynchburg by 1840 and reached to Buchanan in Botetourt County by 1851. The plan was to then dig a 1900 foot tunnel through the mountains west of Buchanan, but that part of the project was abandoned after 1.5 million dollars had been spent and it had not been completed.

In 1854 the Tidewater Connection opened in Richmond, linking the Great Basin to the navigable waters of the James below the Falls. Another branch reached Lexington, Virginia in 1860.

By that time there were 197 miles of canal including 37 miles of slackwater (no rapids) river. It was 40 to 50 feet wide and 5 feet deep. There were 90 locks raising boats a total of 728 feet, 23 feeder dams, 12 aqueducts, 198 culverts, and 135 bridges. The only method of digging had been to use blasting powder and hand shovels. Many lives were lost, but their numbers were not recorded for they were mostly those of slaves and Irish immigrants. At least 11 million dollars was spent just on the construction of the canal from Richmond to Buchanan.

The peak year of operation was 1860, when canal boats carried almost [illegible] quarter of a million tons of tobacco, corn, lumber, iron ore, coal, stone, whiskey, wheat, and other cargo. At the time, it was the only method of transporting heavy or bulky goods across Virginia.

Unfortunately the builders had not anticipated the tremendous



Great shiplock
at 26th Street

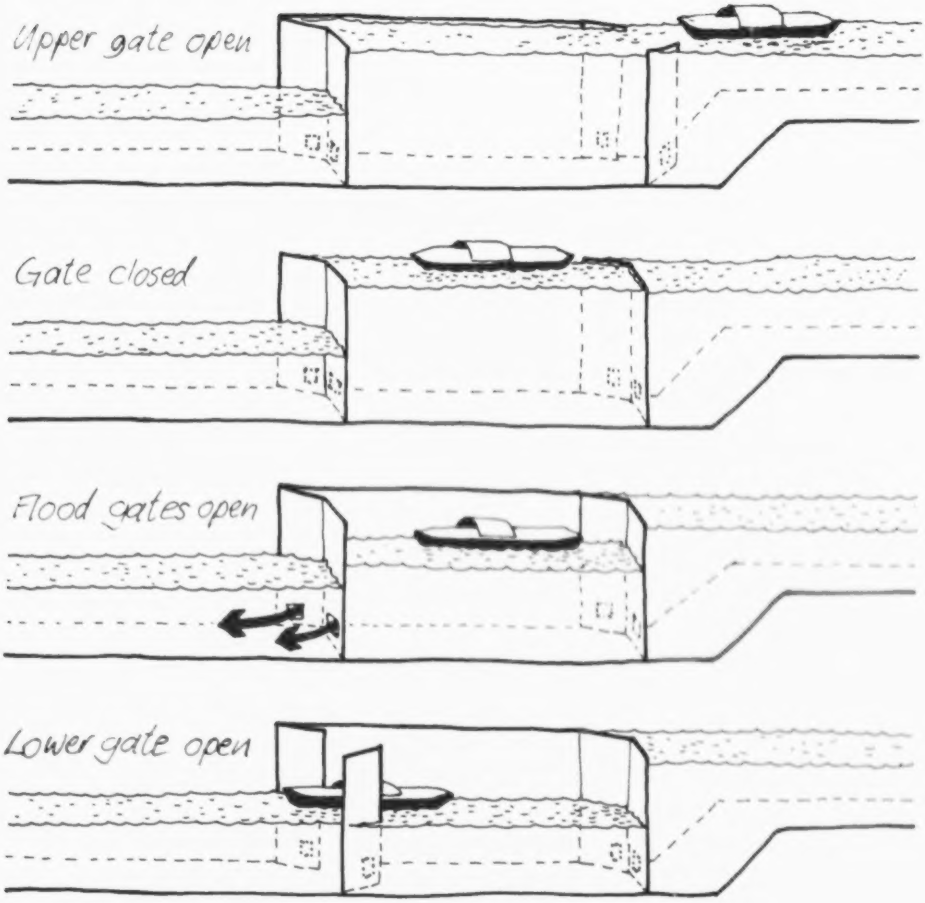
number of maintenance problems that began cropping up. The muddy water began silting and filling up the canal. The clay lining leaked and eroded the berm (the bank between the canal and the river). Floods washed out banks, locks, and the towpath. Droughts nearly every summer dried it up so that dams had to be built across the river to channel water into the canal.

The Civil War began the final downfall of the system when maintenance work and all improvements stopped abruptly. In 1865 General Sheridan wrecked the locks and banks for 90 miles above the Falls. An 1877 flood finally finished it off and in 1880 the railroad purchased the company to use the towpaths for railroad beds. The new technology (railroads) was cheaper, easier to maintain, and faster than the old method of water transportation.

Information taken from the following sources:

David D. Ryan, *The Falls of the James* (William Byrd Press, Inc., Richmond, 1975) pp. 63-64.

Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985) pp. 95-104.



Boat moving downstream through canal locks.
This process is reversed for a boat to move upstream.

Procedure Discuss the origins of the canal with the students beginning with George Washington's dream. Why do you think Washington wanted a canal? Why didn't he plan a road instead of a waterway to the west?

What kind of problems do you think the builders of the canal encountered with the rocks on the river in Richmond? Why did they have to continue the canal even after they got around the Fall Line in Richmond? (The water even above the Falls is often shallow and rocky, especially when the water level is low.)

Why do you think it took such a long time (1785 to 1851) to finish the canal as far as Buchanan?

Have the students do one or more of the following activities:

Draw a mural showing the route of the canal from Richmond to Buchanan.

Draw a picture of the canal, the towpath, and the river.

Draw a picture or make a model of a set of locks showing how the water level was raised and lowered for boats.

Pretend you are one of the men helping to dig the canal. Write a diary telling what the work is like.

Obtain a copy of *A Guide to the Works of the James River & Kanawha Company from the City of Richmond to the Ohio River*, prepared for the Virginia Canals and Navigations Society by W.E. Trout, III, First Edition, April 1986. (Copies are available from Richard A. Davis, VC&NS Sales, Rt. 2, Box 254, Lexington, VA 24450 $2.50 ppd.)

Find a section of the river with which you are familiar and read the description of the canal in that location in the "Guide".

Take a field trip to a section of the canal which is still visible to see how big (or how small) it actually was. Try to imagine digging out the dirt with nothing but shovels and picks. Read about this section of the canal in the "Guide".

Social Studies

SOL: 4.6, 4.7, 5.1, 5.7, 5.8, 5.10, 6.2, 6.4, 7.8

IIIb, IIIc, IIIe

Skills: mapping, making inferences, interpreting models

FLOUR POWER

OBJECTIVES The student will describe the growth and decline of flour milling which used the water at the Fall Line in Richmond for power.

METHOD Students will construct a replica of a water wheel, draw a picture of a water powered flour mill, and/or draw a mural showing the location of some of the flour mills along the James River Fall Line in the 17th through the 19th centuries.

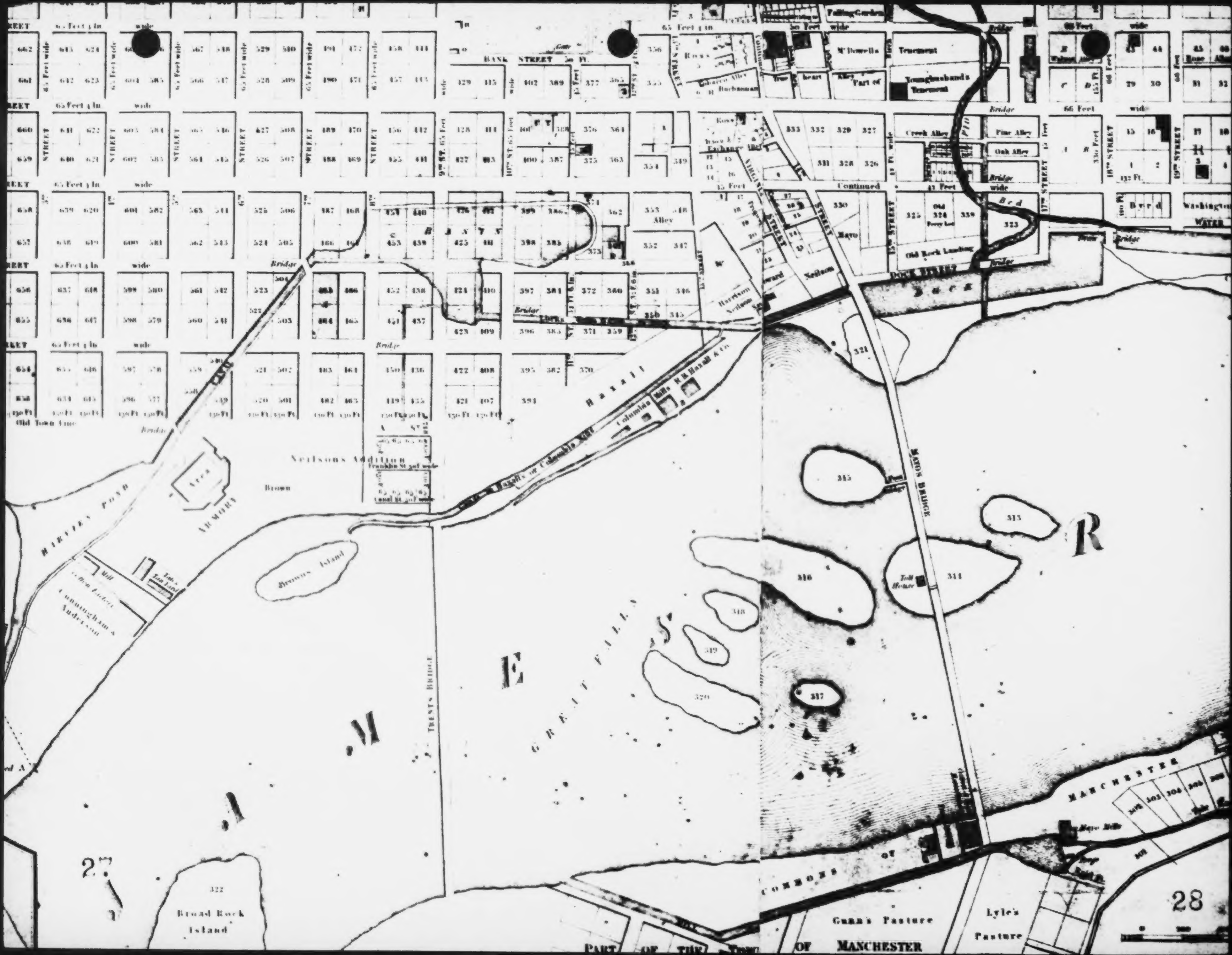
BACKGROUND The rushing water at the Fall Line may have stopped boats travelling up the river, but it presented an opportunity to others who harnessed the power for milling flour. Even before William Byrd founded Richmond in 1742, he set up two flour mills in the town of Manchester (which became part of the city of Richmond in 1910) and milling operations continued in the area until 1930. These were the first industries to develop in the Richmond area and they were the direct result of the abundance of swiftly moving water to turn the wheels.

By the 1790's farmers were growing wheat and other grains upstream and carrying it down to the mills in Richmond on bateaux, which were long, flat boats (see the activity called ROW YOUR BOAT for more information about river boats). The ground flour was then shipped down the James, out the Chesapeake Bay, to destinations all over the world. In the early to mid-1800's Richmonders owned a fleet of three dozen large schooners and brigs which carried flour to South America, San Francisco, and as far away as Australia. Three hundred thousand barrels were shipped in 1853. Sometimes farmers with grain (especially corn) who were located some distance from a mill, converted their grain into whiskey ("corn squeezins") which was easier to transport than the grain itself!

The most successful mills were located on the rapids between Hollywood Cemetery and Mayo's bridge and on the Great Basin of the Kanawha Canal which was completed in 1800. The largest were the Gallego and the Haxall Mills, with the Gallego being the largest stone ground flour mill ever built, occupying the largest brick building in America. It was started in 1834 by Joseph Gallego and located at 12th and Canal Streets on the Great Basin. After an 1848 fire it was rebuilt as a 7-story mill. In 1860 a 12-story mill was built adjacent to the first. Both mills burned in the 1865 evacuation fire, but the larger was rebuilt and operated until it burned again in 1903.

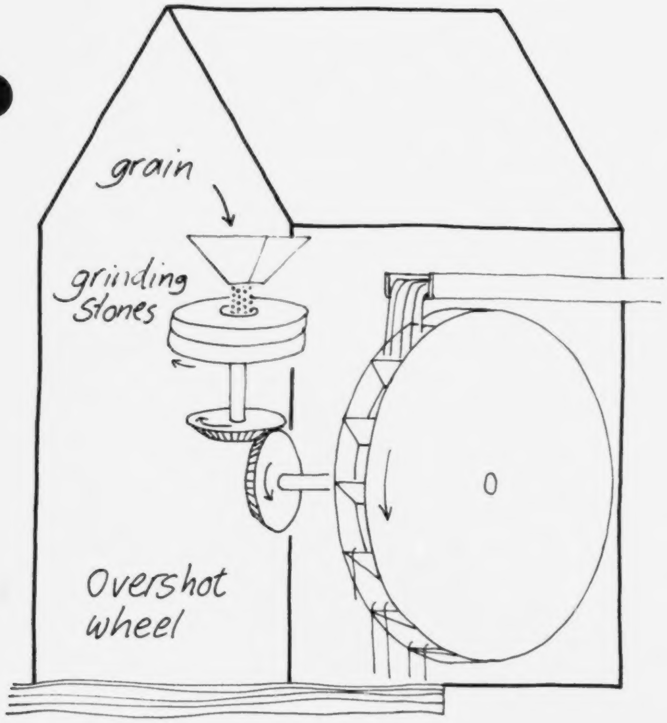
Dams or levees and canals were often constructed to divert as much water as possible from the river to the water wheels of the mills. The Haxall Canal on the north bank and the Manchester Canal on the south bank were both used for this purpose. (See the map of Richmond in this guide for the location of these structures.) The Haxall Mills operated from 1809 to 1894 and eventually spread over several blocks.

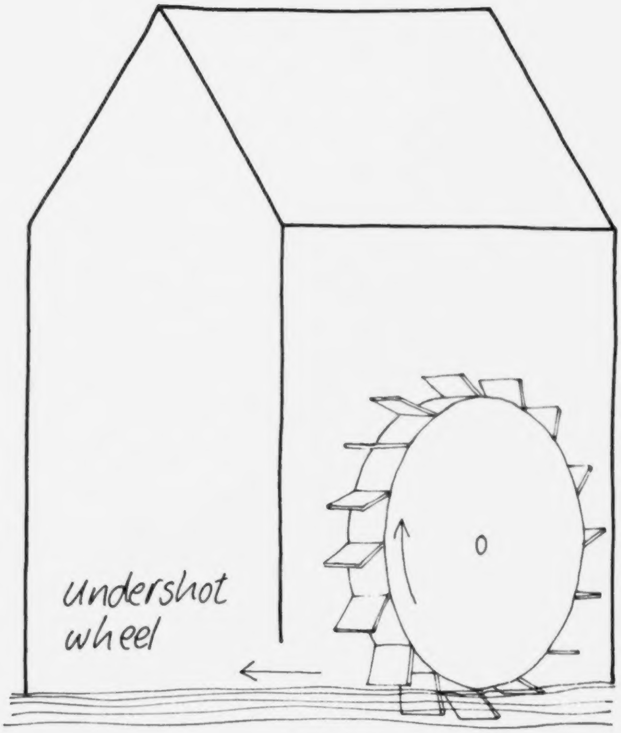
The river gave the mills power, but it also gave them trouble from time to time. In the early 1800's the mill wheels halted during the hot, dry days of late summer when the water level in the river dropped significantly and even the dams and canals couldn't provide enough water to turn them. Farmers with their loads of wheat camped in lines leading up to the mills waiting for their turn. Sometimes the opposite problem arose and floods ripped through the mills, but they were usually rebuilt on a larger scale since labor was relatively cheap.


BANK STREET
65 Feet 4 In wide
9th ST.
10th ST.
VIRGINIA STREET
15th STREET
17th STREET
18th STREET
19th STREET
Falling Gardens
McDowells Tenement
Younghusbands Tenement
Tobacco Alley
Exchange Alley
Creek Alley
Pine Alley
Oak Alley
Continued
Old Rock Landing
DOCK STREET
DOCK
Byrd
Washington
Harrison
Neilson
Haxall
Columbian Mills
R. R. Haxall & Co.
Haxall's or Columbia Mill
Bridge
Locks
Neilsons Addition
Franklin St
Brown
Armory
Haxall's Pond
Browns Island
Cunningham & Anderson
Mill
Old Town Line
Trents Bridge
GREAT FALLS
J A M E S R
Mayos Bridge
Toll House
Broad Rock Island
Mayo Mills
Commons of Manchester
Gunns Pasture
Lyle's Pasture
MANCHESTER
PART OF THE TOWN OF MANCHESTER
27
28

Dunlop Mills in 1865,
at the south end
of Mayo's Bridge.

The July 1984 issue of *Scientific American* contains an excellent article about the history of water power for teacher background information.





Until the War Between the States, Richmond was considered the flour milling capital of the country, hemisphere, and perhaps the world. During the 19th century only tobacco surpassed flour as Richmond's largest commercial product. During the War the mills operated at less than full capacity because they were unable to obtain sufficient grain to grind. The ships that were used to export the flour were either captured by the Union army or sunk by the Confederates to block the James River channel so that northern forces could not sail up to Richmond. Eventually competition from mills in Baltimore, New York, Boston, and Minneapolis crippled the Richmond flour milling industry even further and it never quite recovered. In addition, Virginia's crop land was not as fertile as it once had been and the "grain belt" moved to the Great Plains.

Information taken from the following sources:

Michael B. Chesson, *Richmond After the War: 1865-1890* (Virginia State Library, Richmond, 1981)

Jeffrey Ruggles, Canal Walk Historic Marker Text, Richmond, Virginia, 1987.

David D. Ryan, *The Falls of the James* (William Byrd Press, Inc., Richmond, 1975)

Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985)

PROCEDURE Ask the students to make a list of sources of power that were available to do work before there were electricity, steam engines, or petroleum powered machines. (The sources of energy most frequently used were wind, moving water, and mules or horses turning grind stones.) Explain that water flowing down a relatively steep incline has more power than water flowing slowly along in a flat river or stream.

Next ask them to think of reasons people might have needed to use wind or water power. (Wind mills were sometimes used to pump water out of wells. Water mills on fast moving streams were often used to grind various kinds of grain into flour, one of the basic foods both in earlier times and now.)

Discuss the shape and flow of the James River through Richmond and why the area known as the Fall Line was a prime location for flour mills (see the activity called FALL LINE CITY for more information). Use the illustrations and the information in the Background section above to discuss the development of Richmond's flour milling industry.

Discuss the problems for flour mills created by both high and low water in the river. What purpose did the canals serve for the flour mills?

Have the students do one or more of the following activities:

Construct a cardboard, wooden, or metal replica of a water wheel and show the class how the movement of the water makes it turn.

Draw a simple diagram of a flour mill and describe how it works.

Draw a mural of what the James River must have looked like in the early 1800's between Hollywood Cemetery and Mayo's Bridge with mills and their water wheels all along both the north and south banks.

Social Studies

SOL: 4.7, 4.10, 5.7, 5.8, 7.1, 7.3, 7.9

IIIb, IIIc

Skills: interpreting models

PULL OR POLE OR ROW YOUR BOAT

Objectives The student will (1) describe various boats that were used on the James River and in the Kanawha Canal during the 18th and 19th centuries, (2) tell what they were generally used for, and (3) describe how they were powered.

Method Students will write a creative story about a boat trip, participate in a boat-building contest, observe a demonstration of poling a boat upriver, and/or find newspaper articles about the 1986 James River Bateau Festival.

Background In the mid and late 1700's, more and more people settled in the western part of Virginia. Roads were either nonexistent or impassable much of the year due to mud and deep ruts, so the river was still the best (although an unpredictable) method of travel and transportation for goods. Several different types of boats were used extensively for the next 100 years to move across or up and down the river.

FERRY BOATS The General Assembly mandated public toll ferries along the river primarily to promote unity among the various parts of the colony. By 1700 there were 51 public ferries on the James River and its branches.

Most of the ferries couldn't operate regularly because the river was so temperamental. Ferry owners were allowed to construct taverns or "ordinaries" to feed and shelter travelers (sometimes for several days at a time) while they waited for high water to subside. Since the tavern owners made considerably more money providing room and board than they did from the low tolls for a ferry crossing, they had little incentive to keep the ferry on a regular schedule.

If a traveler arrived at a crossing on the opposite side of the river from where the ferry operator lived, he would ring a bell (or simply fire a gun) to call the ferrier. Then the owner would row the boat across the river to pick up the passenger and sometimes his horse as well. Towns often grew up around ferry crossings and were named for the families who ran them. Today these towns are quiet, small, out-of-the-way places, far from main roads and interstate highways — the modern replacement for rivers as the main route for travelers.

BATEAU(X) Before the James River and Kanawha Canal Company completed the canal upriver from Richmond, farmers were forced to rely on the river itself to transport their tobacco, iron ore, and other goods to market. The Reverend Robert Rose had a plantation on the Piney and Tye Rivers in Amherst County, and in 1749 came upon the idea of lashing two dugout canoes together to carry his tobacco hogsheads to Richmond. This system worked fairly well until the great flood of 1771 when the dugouts were washed away.

Anthony and Benjamin Rucker, brothers who also had a plantation on the Tye, were inspired to invent a boat of sawn lumber which was different enough from other boats at the time to receive a patent in 1772. It became known as the "James River Bateau," (pronounced bat-toe) "Market Boat," or "Tobacco Boat." Their first boat was 50 feet long, four feet wide at the bottom, six feet wide at the top, drew 13 1/2 inches of water, and was capable of carrying 11 hogsheads of tobacco through the shallows and rapids to Richmond. Eventually some bateaux (which is French for "boats") were 60 feet long and eight feet wide.

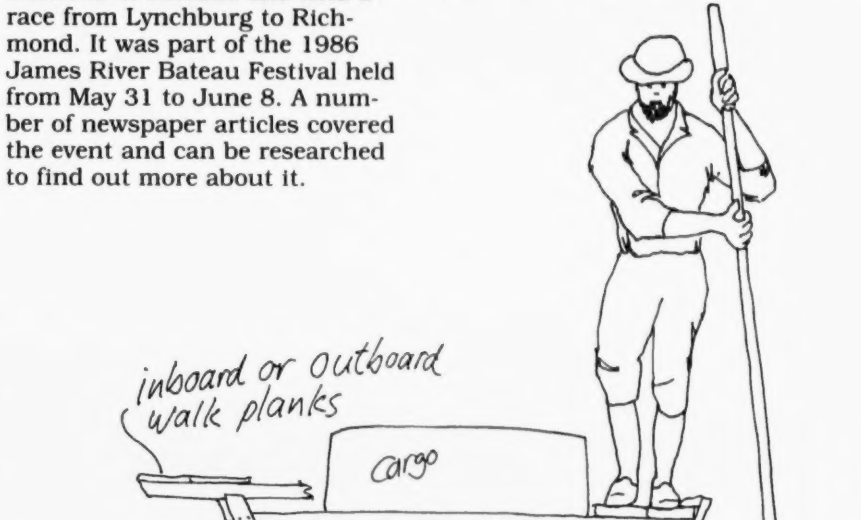
Each bateau needed a crew of at least three, one to steer and two to pole. Often they traveled in groups of three boats down to Richmond, where two boats were sold to lumber-hungry city folk, and the third was poled back upstream carrying goods purchased in Richmond. It was hard, dangerous work with no guarantee of success if the river rose rapidly or if the rocks were too treacherous to avoid. After the Revolutionary War, the James River Company was established to make the river safer for navigation. The company blasted sluices or channels through rock ledges, built loose rock walls called "wing dams" to funnel the river into the sluices, and constructed canals where necessary around the major falls. Except in the short canals, there was no towpath from which to pull the bateaux. The boats simply had to shoot down the rapids and pole back upstream the hard way. (See the activity called KANAWHA CANAL for more information about the development of the canal.)

← bateaux at Maidens

poling a bateau during the '87 Festival

At one time over 500 bateaux plied the James between Lynchburg and Richmond, taking about a week to go downstream and ten days to return.

In 1983 the CSX Corporation began excavating an area in downtown Richmond to construct the James River Center on the site of what was once the Great Basin of the canal where boats turned around to head back upstream. (See the Background section in FLOUR POWER for more information about the Great Basin.) The bulldozers began uncovering old canal boats and all work halted for a few weeks until archaeologists and volunteers could examine what was there. Eventually over 30 mud-preserved boats were found with three in good enough condition to salvage. The discovery sparked the interest of Virginians along the James River and several individuals and towns built reproductions of bateaux and held a race from Lynchburg to Richmond. It was part of the 1986 James River Bateau Festival held from May 31 to June 8. A number of newspaper articles covered the event and can be researched to find out more about it.


inboard or outboard walk planks
cargo
round sides
flat bottom

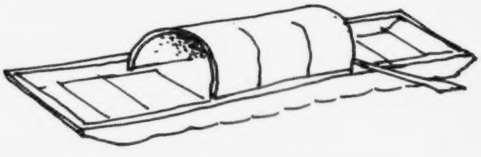
PACKET BOATS Once the canal was dug, it could accommodate packet boats, which carried passengers and were pulled by mules walking along the towpath. These vessels were from 70 to 80 feet long and were 11 feet wide. During the 1850's six of these boats carried tourists on the 33-hour journey from Richmond to Lynchburg for a little over five dollars per person. Although the quarters were cramped, it was a leisurely trip with pleasant scenery. Following is a description of a trip taken in 1864 from Richmond to Dover Mills in Goochland County.

It was with joyous hearts and great expectations that we started on our journey . . . The mode of travel on the canal was something astonishing. A ditch filled with slimy water, snakes, and bullfrogs, and fringed along its banks with lily pads and weeping willows, furnished the waterway for a boat, called The Packet, built very much upon the plan of Noah's Ark. . . .

At five o'clock in the afternoon, the good ship . . . departed from the packet office in Richmond. Its speed may be calculated from the following data: starting time, already given; distance traversed, twenty miles; destination reached at ten thirty p.m.

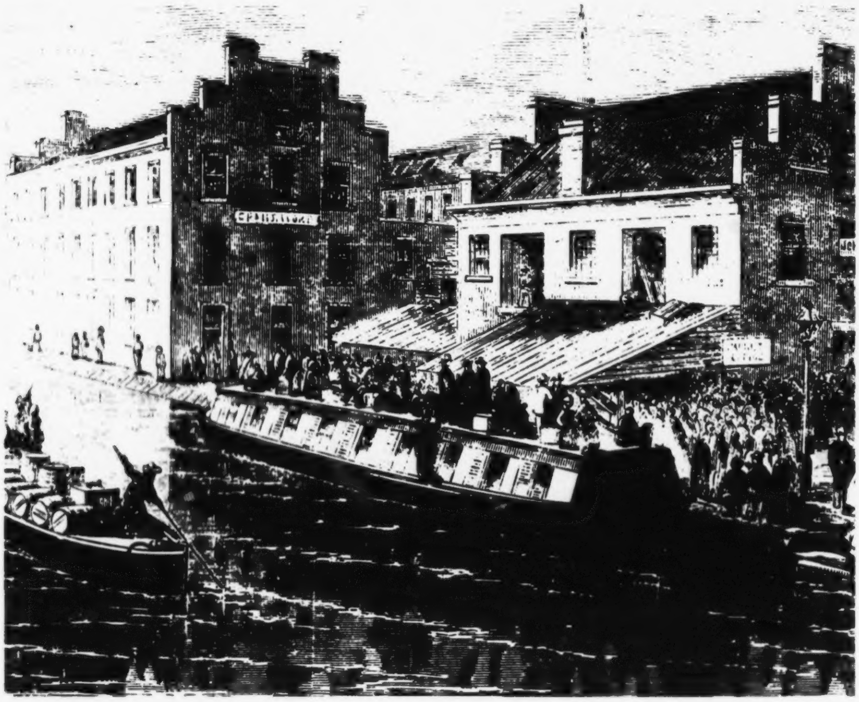
That boat was a curiosity. It was a shell divided into four main compartments. The forward and largest compartment was for passengers; behind it was a kitchen, then a compartment for servants, and lastly, the captain's room in the stern. . . . On either side of the boat were many windows . . . The freight and baggage were on the deck above the heads of the passengers. The deck, even in winter, was preferable to the stuffy cabin . . . The terrors of such a trip were mitigated by the beautiful scenery through which the lazy outfit wound its way.

The weather was very pleasant; and the young folk and the soldiers, of whom there were a number on board, contented themselves . . . with seats upon the trunks, bags, and barrels upon the deck. . . . Even this poor privilege was not without its accompanying danger, for the canal was spanned by many bridges. . . . These bridges were so low that the passengers were constantly warned by the helmsman's cry of "Low bree-g-e!" and compelled to squat very low to avoid being scraped off the deck. The situation was always ludicrous, and the accidents resulting from these low bridges were numerous, sometimes serious, but oftener absurd. Old Aunt Dinah . . . was on one occasion caught unaware by a low bridge and deposited feet downward in the water, dressed in the latest style of the day, which was providentially a hoop-skirt. Her whoops were strong, but her hoops were stronger. The former exhausted, but the latter retained the air, and she floated gaily to the shore unharmed save from fright and footwashing. [1]



BARGES Although tourists obviously enjoyed a trip up the canal, the profit was much greater for transporting goods, not people. During the heyday of the canal, over 200 freight barges were in constant use, carrying lumber and agricultural products east (including a fair amount of corn whiskey from the mountains), and returning west with staples and general supplies. Barge crews were even known to stop and help a farmer finish harvesting his crop so they could load the wheat on the barge and carry it to the flour mills in Richmond. In the peak year of canal commerce, 1860, almost a quarter of a million tons of goods moved along the waterway. (See the activity called FLOUR POWER for more information about mills.)

It was still not an easy journey, however. The section of the River through Balcony Falls west of Lynchburg was never quite tamed. In 1854 a canal boat carrying 50 people broke loose from the tow line during high water. The boat was washed over Mountain Dam and hung tentatively on a rock. Several people jumped from the boat to the rocks in midstream. Three slaves and two white men came to the rescue, fighting the rapids to tow the passengers ashore. Frank Padgett, the slave who led the successful rescue, was drowned in the attempt. The boat's captain later erected a granite memorial to Padgett which still stands today.



Packet boat at Richmond Packet office

[1] *American Canals* Bulletin of The American Canal Society, Bulletin Number 48, February 1984. Editorial Address — Box 310, Shepherdstown, W. VA. 25443.

Other information taken from the following sources:

H. Roger Corbett, *Virginia White Water: A Canoeing Guide to the Rivers of the Old Dominion* (Seneca Press, 1977).

W.E. Trout, III, *The Bateauman's Guide to the James* (Virginia Canals and Navigations Society, First Edition, Second Printing, March 1986). Copies available $1.50 ppd from Richard A. Davis, VC&NS Sales, Rt. 2, Box 254, Lexington, VA 24450.

Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985)

Materials
Activity A — shallow pan with water, (wallpaper tray makes a good model of a canal), toy boat, sponge or other flat, floating object, straw or a pencil.

Activity B — Richmond area newspapers May–June 1986, article entitled "Determined crew poles bateau back up James River," Richmond Times-Dispatch, Sept. 15, 1986

Activity C — Each small group of students needs: plasticene or other modeling clay that is not water soluble (Play Doh won't work!) or a small piece of aluminum foil, shallow pan with water, washers, marbles, or other objects to use as weights.

Procedure Look at the pictures of the various types of boats used along the James River and on the canal in the 18th and 19th centuries.

Discuss the design and uses of the different vessels with the students.

Have the students do one or more of the following activities:

ACTIVITY A — Show them the picture of how bateaux crewmen poled their boats upstream and demonstrate the technique using a toy boat (or sponge or anything flat that floats) in a pan of water with a straw or a pencil for a pole.

ACTIVITY B — Have the students find news articles in the library about the "1986 James River Bateau Festival", held May 31 through June 8. Ask them to find information such as:

How many bateaux were entered in the race?

What cities and towns participated in the festival?

Was the race traveling downstream or upstream? Which direction would be more difficult?

What were some of the problems encountered by the modern boatbuilders?

Read the article from the Richmond Times-Dispatch, Sept. 15, 1986, entitled "Determined crew poles bateau back up James River". What did Joe Ayers and his crew attempt to do? Why were they doing this? What problems did they encounter?

ACTIVITY C — The Great Boatbuilding Contest

Give small groups of students a shallow pan with water in it and some clay or a small piece of aluminum foil. Ask them to use the clay or foil to design the basic hull shape of a boat that can carry a heavy load (such as the boats that used to carry hogsheads of tobacco downriver).

Once a group has fashioned a boat, have them see how many marbles, washers, etc. they can put in it before it sinks. Let the students revise their designs and use some trial and error until they are satisfied they have the best boat they can make.

If you would like to have a contest to see which group can fashion a boat to hold the heaviest cargo, weigh the pieces of clay using a balance scale or measure the piece of foil so each group has exactly the same amount.

After all of the groups have arrived at their best design, compare their results to see how they are alike and how they are different. Ask them to compare their best boats (those that can hold the most) to those that traveled the river and the canal in the 18th and 19th centuries carrying heavy cargo. What kind of shape seems to work best?

An alternative is to allow students to use cardboard, wood, etc. and build a model similar to an actual canal boat. Most likely their models won't float, but they can be used to illustrate boat designs.

ACTIVITY D — Read aloud the description of the trip on the Packet Boat from Richmond to Goochland found in the Background section above. Have them calculate the speed of the boat in miles per hour. Also tell them the story of the canal boat accident at Balcony Falls and the rescue attempt by Frank Padgett. Next describe the journey that bateaux made downriver to Richmond and back upstream again. Explain the problems travelers had with getting across the river on ferries when the water was high or the weather was bad.

Ask the students to write a creative story about a journey on one of these types of boats. Have them describe the boat, the scenery, their feelings as crewmen or passengers, their reason for making the trip, what the boat was carrying, etc.

ACTIVITY E — Take a field trip to see one of the bateau reproductions built for the 1986 Festival. Mr. Joe Ayers, Route 6, Columbia, Virginia, (804) 842-3573 will show students his boat, sing period songs, and even take people on a boat ride.

"Determined crew poles bateau back up James River."
Richmond Times-Dispatch
September 15, 1986

By Overton McGehee
Times-Dispatch state staff

BENT CREEK—Rock by rock, rapid by rapid, a few men have poled a 2-ton wooden boat upstream on the James River for 110 miles.

They set out in early August to pole the 1770s-style James River bateau from Richmond to Lynchburg. Their mission was to deliver the 49-foot boat to Lynchburg's

Riverfest and to demonstrate that the bateaux that dominated James River commerce 200 years ago were designed to carry cargo upstream, against the current, as well as downstream.

On Friday, after 14 days spread over two different months, Joe Ayers and a crew that had dwindled to his two 18-year old sons, Chris and Eric, reached Bent Creek. They were less than 30 miles from Lynchburg, but also less than 24 hours from their appointment at the festival Saturday morning. To meet the deadline, the bateau had to make the last leg of the journey by truck.

Despite the boat's undignified passage over the final leg, Ayers demonstrated how the bateaux were propelled upstream through white water, an art that began to die out when the James River and Kanawha Canal was built in the early 1800s. In one 13-mile stretch, from Bremo Bluff to Scottsville, the bateau climbed through rapids that totaled 55 feet in elevation.

"You learn more about the river going upstream," Ayers said. "It's worth five trips downstream." The crew found and used some of the sluices that were blasted and chiseled through rapids to improve bateau travel in the 1700s.

"We are trying to change some of the public's unfounded conceptions of navigation on this river," Ayers said. "In some ways, bateau navigation was a bigger success than the canal. It required less investment, less maintenance and didn't become obsolete as quickly."

The 190-mile canal along the James was a major engineering feat and was the state's main highway of commerce in its heyday, but it began to face railroad competition soon after it was built.

Ayers and his sons have also learned a bit about the river boatman's daily routine. They traveled alone most of the last three days of the trip, after other volunteers had to return to civilization. They slept crossways on the 6-foot-wide boat and cooked on a hearth near the stern. As the bateau moved up the river in the mornings, the fire under the coffeepot emitted wisps of smoke that merged with the fog rising from the river.

A few riverbank fishermen were treated to the sight of the bateau, the Minnie Lee, easing upstream through white water rough enough to routinely toss canoes against the rocks while it swept them downstream.

As they approached each rapid from downstream, the bateau crew scouted for the best channel through the rocks and worked to line the boat up with the chosen slot. The man at the rudder would shift the rear so the boat lined up perfectly with the current, using the grasslike algae streaming from rocks like a windsock to point out the current's direction.

Once in the rapid, two men holding hickory poles against rocks could keep the bateau from being pushed downstream, even in a strong current. Once a crewman had a firm hold on the river bottom, moving the bateau forward was a simple, though sometimes strenuous, matter of walking down the platform toward the back, moving the boat underfoot. In relation to the river bottom, the crewman was stationary, as if walking a treadmill, but the boat was gaining ground.

"One of the good things about a boat this large, with this design, is that if it gets stuck in a narrow channel between rocks, it plugs up the current and the water starts to lift it," Ayers said. "All the water's out there working to help you.

"I like this feature, too," Ayers said, standing and walking on a gunwale, proving that his weight would not shift or tip the boat. His demonstration was interrupted when he slipped on a wet spot and fell in the bateau, but the vessel still was not shaken.

Going against the current is nothing new for Ayers, a musician from Columbia who delights in the unorthodox. In 1983, Ayers conceived the idea of building a bateau modeled on the remains of ones uncovered in excavations for the James Center in downtown Richmond, where there was once a turning basin for the canal. His neighbors pitched in and built the Columbia, the first modern reproduction of the once-common river boats.

This year, he organized a bateau race from Lynchburg to Richmond. The Minnie Lee first covered this stretch of river in the race, going downstream. Now the bateau has become the first in modern times to travel a long distance of the James going upstream.

Ayers enjoyed seeing surprised expressions when he told people that boats as large as the bateau could travel upstream on the James. Except for some rushed workmanship at the stern, Ayers believes the Minnie Lee is a reasonably authentic, though shorter model of the typical 1770s bateau that traveled both directions on the river.

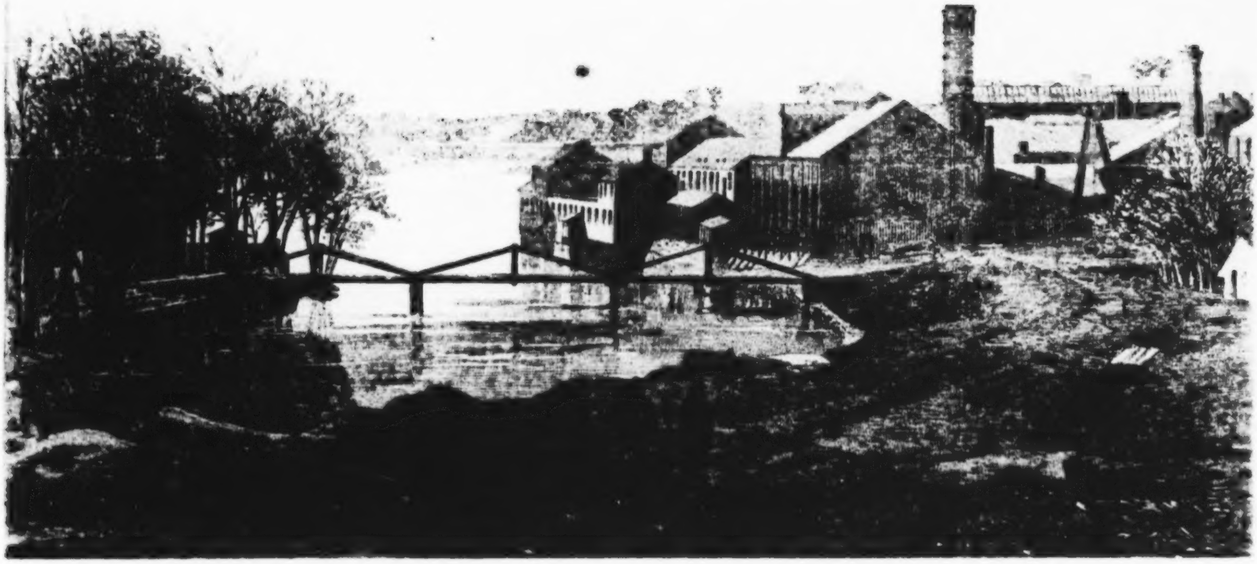
One of the James River bateaux' claims to fame is that Thomas Jefferson helped two brothers named Rucker defend their patented bateau design by writing a letter, which mentions that he was present at the launching of the Ruckers' bateau in 1772.

With a little river mud on them, the ribs of the Minnie Lee are reminiscent of the 200-year-old ones that volunteers in the archaeological dig removed from the mud 20 feet below the level of Cary Street in 1983 and 1984. The next project, Ayers said, might be to build a 75-foot bateau, possibly the most common length in their heyday.

The bateaux, though widely publicized in Virginia during this summer's race, may have more widespread fame soon. National Geographic has photographed the Minnie Lee, and Ayers said he expects the national magazine to publish a piece about the bateaux next spring.

Ayers looks forward to more trips and races on the James, introducing more people to moonlight on the water, wet sand in the shoes and other joys of the boatman's life. "All you really need are some dry clothes at five o'clock," he said.

"There were a lot of worse ways to make a living than as a boatman on the James. Last night, when the sun was setting, I played the flute and the boys poled the bateau."



IRON & INDUSTRY

Social Studies

SOL: 4.6, 5.3, 5.8, 5.10, 7.1, 7.3, 7.10, 9.8, 9.11

IIIc, IIId

Skills: gathering data, making inferences

Iron fence in Hollywood Cemetery

Objectives The student will (1) describe the development and the diversity of industries which grew up along the Fall Line of the James River, and (2) explain their reason for locating in that area.

Methods Students will research the process of smelting iron ore and the making of iron and steel; look for evidence of iron in architectural adornments of the Victorian era; and/or draw a mural depicting the various products of the 19th century industries along the Fall Line of the James.

Background By the mid-1800's a great many industries had sprung up along the banks of the James River in Richmond, all taking advantage of the free flow of water to power their machines. There were mills for coating paper, cutting wood, spinning cotton and twine, forging iron, and grinding flour and corn meal. Many had to give Mother Nature a helping hand by building dams and canals to channel the water where they needed it and the evidence of many of these structures remains in Richmond today. The Haxall Canal, located between 8th and 13th Streets, was constructed in 1789 and drew water from the river for a grist mill. The water flowing through that canal was used for one thing and another until 1975, the last use being for cooling by the Virginia Power 12th Street Power Station. As far as anyone can determine, however, the Haxall Canal was never used for any kind of boat traffic.

The Tredegar Rolling Mill, which later became Tredegar Iron Works, was established in 1836. It was one of the largest and most successful iron mills in the nation and became critical to the Southern war effort during the Civil War. Joseph Reid Anderson bought the foundry in 1848 and offered to work for the Southern cause early in the conflict. He sent a telegram which read "Will make anything you want, work night and day if necessary, and ship by rail."[1]

Prior to the Civil War, Tredegar manufactured guns, locomotives, horseshoes and iron steam ships for the federal government, including the iron plating for the USS Merrimac which later became the CSS Virginia. During the war, Tredegar produced 1160 cannon and 90% of all the cannon balls and shot for the Confederacy. According to a former Tredegar president, the mill was the main reason that Richmond became the capital of the Confederacy and was then the primary reason that Grant wanted to capture Richmond. By 1863 it employed 2500 workers. Even after that conflict

"Iron Front" buildings on Main street in downtown Richmond ended, Tredegar continued to produce war materials and provided defense products for the Spanish/American War, World Wars I & II, and the Korean War. It remained in operation at its original site until 1957 when it moved to Chesterfield County, and in 1987 the rolling mill was sold to a Cleveland firm.

Even before Tredegar was established, iron was produced in Richmond. The Westham Foundry at the upper end of the Fall Line was built to produce cannon for the Revolutionary War. There eventually were more than 30 iron-making companies at the Fall Line and by 1900 they were turning out everything from nails to railroad rails to steam locomotives. They were located here primarily to take advantage of the water power, but a ready supply of coal from Midlothian and iron ore which was barged in from the mountains assured their success. They grew quickly to meet the demand for rails as the railroad companies began to lay lines all over Virginia, and although their reliance on running water for power diminished over the years, they often remained in or near their original locations.

The early settlers built the first ironworks in the New World on Falling Creek in what is now Chesterfield County. It didn't operate for very long, but it certainly set a precedent in the area. There was some low grade iron ore in central Virginia, but large quantities of a better quality ore were more readily available in the mountains. Tredegar used iron from at least 25 different furnaces from as far away as Allegheny County and drew heavily on the many located in Botetourt and Rockbridge Counties.

Another industry which took advantage of the river was the Albemarle Paper Manufacturing Company which constructed its mill below Hollywood Cemetery in 1887. Process water for the mill was drawn from the river and the canal and is still used by the present day James River Paper Company to turn a water wheel which produces electricity for their operations.

In 1890 the Richmond Railway and Electric Company used water in the Haxall Canal to generate electricity for the trolley cars on the streets of Richmond. Several other hydropower/steam plants also produced electricity for industries and/or the city. (See the activity called FALL LINE CITY for a list of various water-powered industries that have operated in Richmond.)

[1] Ed Crews, "Arsenal of the Confederacy Closing Down," Richmond News Leader, Wednesday, March 18, 1987.

Other information taken from the following sources:

Kathleen Bruce, *Virginia Iron Manufacture in the Slave Era* (Augustus M. Kelley, New York, 1968)

Jeffrey Ruggles, Canal Walk Historic Marker Text, Richmond, Virginia, 1987.

David D. Ryan, *The Falls of the James* (The William Byrd Press, Inc., Richmond, Virginia, 1975)

Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985)

Procedure Discuss the development of industries which depended on the water of the Fall Line for power. Help the students see the reason for locating the mills here even though their raw materials came from elsewhere in Virginia.

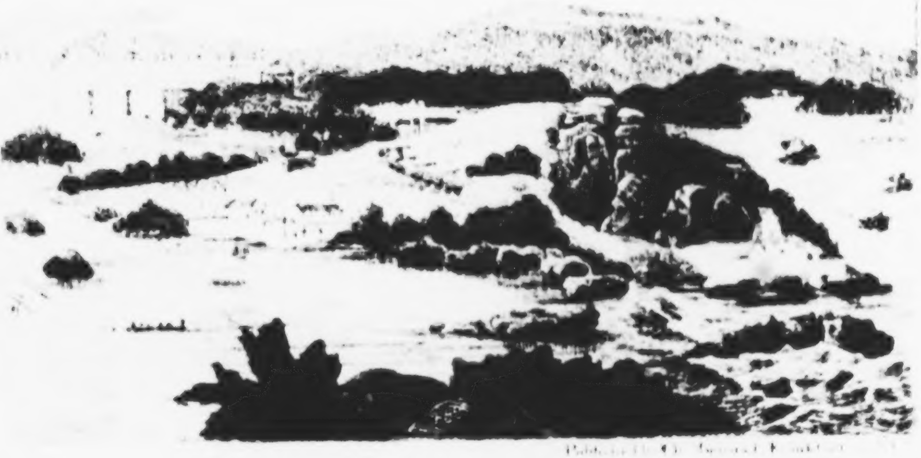
Have the students do one or more of the following activities:

Find out more about the processes used to make iron in the 19th century. What was the purpose of the iron furnaces, what did they look like and how did they operate? (Note to the teacher — There is a piece of slag from the Belle Isle iron factory in the kit accompanying these materials which is located in your school division central office. It can be used to illustrate part of the process of manufacturing iron.)

Make a list of things for which iron and steel were used in the 19th century and another list describing how we use them today. How are these lists similar and how are they different? Which uses might you predict will continue on into the 21st century?

Decorative iron works were popular as architectural adornments in the 19th century. Many are still in evidence around the Richmond area in homes, business buildings and cemeteries. Examples are the "Iron Front" buildings on Main Street in downtown Richmond. Have students look at pictures of these structures; take a walking tour of an older section of town which features some of these iron works; or encourage the parents of your students to take them on a history tour of the Fan, Hollywood Cemetery, downtown Richmond, or any other area which is appropriate.

Make a mural or collage illustrating the various products that were and are made using the water power of the James River. Do we depend as much on water power today as we used to? Why or why not? What are the advantages and disadvantages of hydropower as a method of generating electricity? (You can contact Virginia Power, Energy Education Programs, P.O. Box 26666, Richmond, VA 23261, 804-771-3782 for more information about hydroelectricity generation.)



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BELLE ISLE Richmond Va.

TRAMP! TRAMP! TRAMP!

THE

PRISONER'S HOPE.

The music of this song can be obtained at the well known **Music-Store**
of Frederick Blume, 208 Bowery, New York.

◆

In the prison-cell I sit,
Thinking, Mother dear, of you,
And our bright and happy home, so far away!
And the tears they fill my eyes,
Spite of all that I can do,
Tho' I try to cheer my comrades, and be gay.
Tramp, tramp, tramp! the boys are marching:
Cheer up! comrades, they will come,
And, beneath the Starry Flag,
We shall breathe the air, again,
Of the Free-land, in our own beloved home.
CHORUS: Tramp, tramp, &c.

In the battle-front we stood,
When their fiercest charge they made,
And they swept us off, a hundred men or more;
But, before we reach'd their lines,
They were beaten back dismayed,
And we heard the cry of Vict'ry, o'er and o'er.
Tramp, tramp, tramp! &c.

So, within the prison-cell,
We are waiting for the day
That shall come to open wide the iron door
And the hollow eye grows bright,
And the poor heart almost gay,
As we think of seeing home and friends, once more
Tramp, tramp, tramp! &c.

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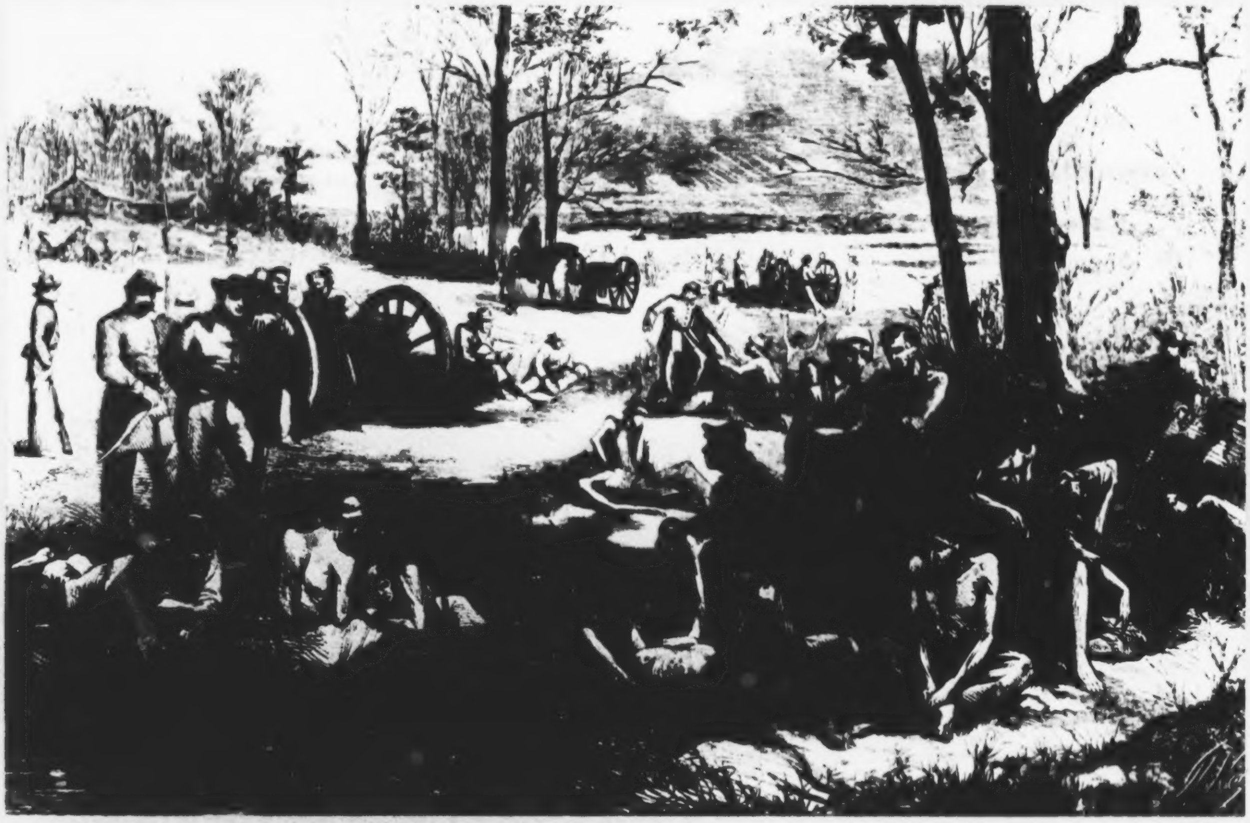
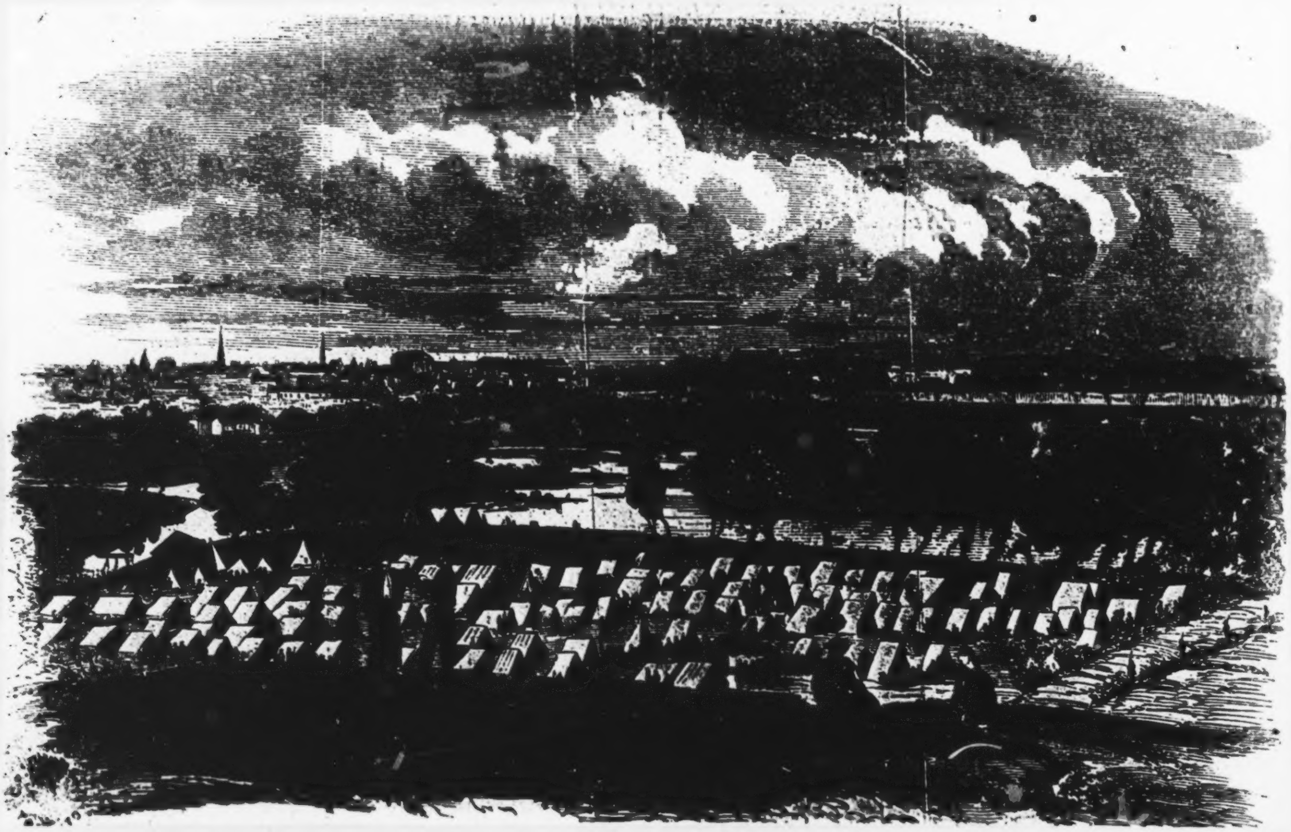
PLIGHT



OF THE PRISONER



Social Studies

SOL: 7.1, 7.4, 7.7, 8.8, 8.9

IIIf

Skills: making inferences

Objectives The student will recognize the influence of propaganda and bias on the description of historical events.

Method The student will write a poem, letter, or story, or will take part in a role play describing conditions in a Civil War prison camp such as the one located on Belle Isle, first from the point of view of a Northern prisoner and then from the perspective of a Southern soldier guarding the prisoners.

Background In 1862 Belle Isle was turned into a prison camp for Northern enlisted soldiers. Although the living conditions on Belle Isle were poor, they were not really any worse than those in other Southern prisons and in some Northern prisons as well. See the HISTORY OF BELLE ISLE for more information about the Belle Isle prison camp.

As in many other situations, the descriptions of prison conditions were often biased depending upon which side of the conflict the artist or narrator stood. Sometimes it is relatively easy to detect bias, but not as easy to find out what the true circumstances were.

Procedure Have the students do one or more of the following activities:

Look at the two engravings in this activity, each of which is supposed to depict the prison camp on Belle Isle during the Civil War. Which do you think was done by a Northern artist and which by a Southerner? How accurate do you think these portrayals were? Why do you think there would be such a contrast in the two different images of the same place?

Read the poem "The Prisoner's Hope." The author refers to the prison cell. Did the encampment on Belle Isle have "cells" as we normally think of them? Do some research to find out more about the conditions in Southern prison camps. When were the accounts you found written? Do you think they are less likely to be biased if they are written near the time of the event or if they are composed at a much later date? Does time guarantee objectivity? What problems other than bias might influence factual accuracy after a length of time has elapsed?

Write a poem, a letter, or a story as if you were a Northern soldier imprisoned on Belle Isle. Describe the living conditions, food, and scenery around you. *Next* write a report as if you were the Southern officer in charge of Belle Isle, telling how you are treating the prisoners.

Read the following report of a participant in a 1986 walking tour which happened upon a group of Civil War re-enactors staging a burial detail on Belle Isle.

"Do any of you kind people have any food? Newspapers? Cigars?"

The negative response drew a resigned shrug. The forlorn looking Yankee was part of the 20th Division of Maine Volunteers. He had been captured near Warrenton.

"I was picked up by Mosby's Raiders."

"You're lucky to be alive, son," said his gray-clad jailer, watching him over the barrel of an Enfield rifle. They jawed a little bit back and forth over the war news. This was August of 1864.

"So, hey, Reb, how could we get you to part with a little extra food?"

"I might could be persuaded in return for a little information."

"Ask him if he extends credit," chimed in another prisoner.

"I extend credit to them that looks healthy," the guard answered wisely. At this point the island was losing 500 prisoners a month. Dysentery was the big killer.

"Them ground up corncobs they put in the bread give us diarrhea," complained a prisoner.

"Listen Yank, you best be thankful for what you've got."[1]

Use the information you have learned about Civil War prisons to stage your own re-enactment of a typical scene or invite a group of real re-enactors to perform a living history skit for your class. There are several re-enactment groups in the Richmond area who are willing to speak to or perform for school groups. Contact either of the individuals listed below for more information:

Herbert S. Wheary
Public Affairs
P.O. Box 26666
Virginia Power
Richmond, VA 23261
771-4122

Richard Cheatam
Maymont Foundation
1700 Hampton Street
Richmond, VA 23220
358-7166

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[1] Kathleen Hancock, *Richmond News Magazine*, October, 1986.

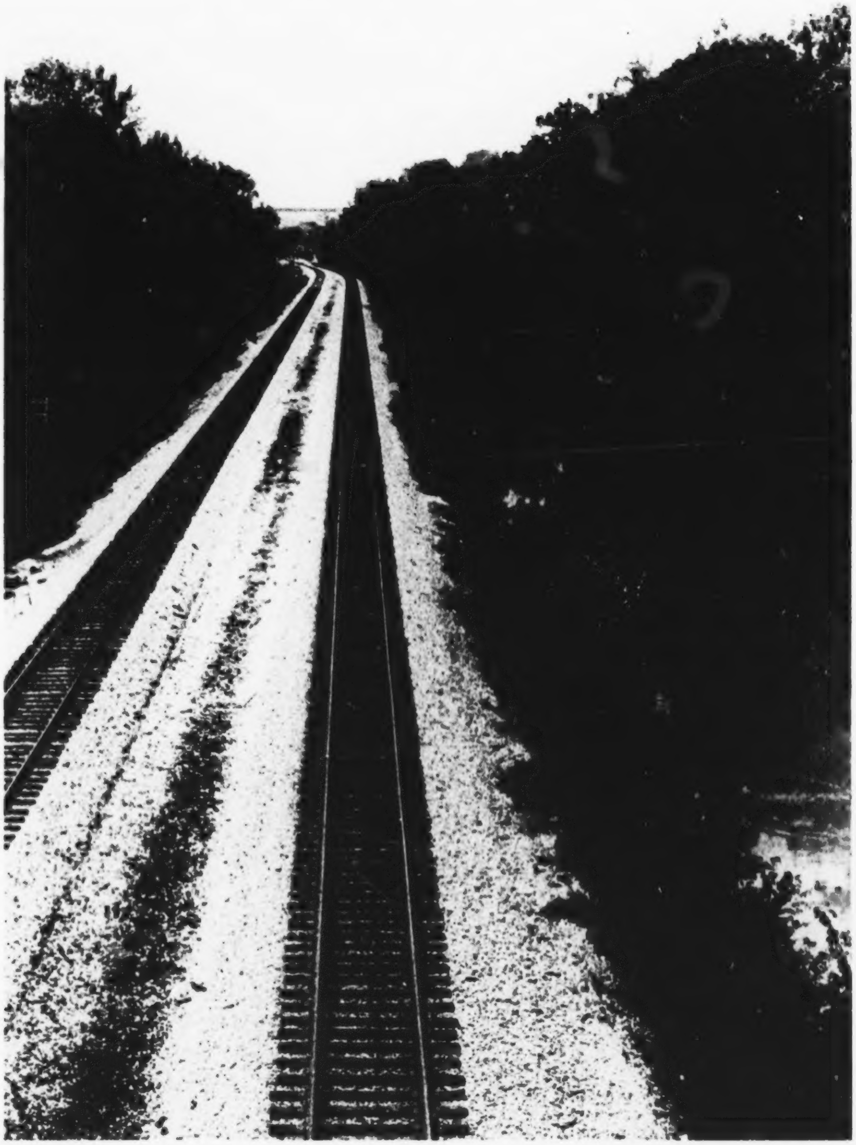
Social Studies

SOL: 5.7, 5.8, 5.10, 7.1, 7.3, 9.6, 9.8, 9.9, 9.11

IIIb, IIIc

Skills: gathering data, making inferences, determining cause and effect

A TALE OF TWO CITIES



Objectives The student will (1) draw a time line to scale, and (2) describe the effect that new technological developments have on lifestyles and the growth and decline of communities. The specific example used will be the replacement of the James River and Kanawha Canal by the railroads as the major means of transporting goods in central Virginia.

Method Students will draw a time line to scale showing the beginning, development, and demise of the James River and Kanawha Canal and the advent of railroads in Virginia. They will also write a series of short news articles focusing on the fortunes of two Piedmont towns — Scottsville and Charlottesville.

Background The James River and Kanawha Canal was the result of George Washington's dream to connect Virginia with the territories to the west. From 1785, when it was begun, until 1880, when it was finally sold, tremendous amounts of time, labor, and money were poured into the canal and it served as the major method of transporting goods across Virginia for several years.

From the beginning, maintenance of the canal was a major problem. It was heavily damaged during the Civil War, but was repaired completely until a flood in 1870 damaged major sections again. Money was allocated to repair it one more time, but an even bigger flood in 1877 was its death knell. In 1880 the James River and Kanawha Canal Company sold the canal property to the Richmond and Alleghany Railroad Company, which laid tracks on the former towpath. (See the activity called KANAWHA CANAL for more information about the development of the canal.)

Development of the railroads in Virginia began in the 1830's and progressed steadily until, in 1860, there were five railroads terminating in Richmond. They too were damaged during the War, but by 1866 they had been totally rebuilt. In 1881 trains from all over Virginia converged at Howardsville to celebrate the completion of the rails that would join the eastern and western parts of the state. The Virginia Central Railroad, one of the five in Richmond and the one running westward from the capital roughly in the direction of the James River, became the Chesapeake and Ohio Railway Company, which eventually grew to serve nine states. The C & O was nicknamed "George Washington's railroad" because it had succeeded in fulfilling his dream of uniting the eastern and western parts of the United States, although by rail rather than by water as Washington had planned.

The development and demise of the canal and the expansion of the railroad greatly influenced the lives and fortunes of people and towns along their routes. Following is an excerpt which illustrates the effect the canal and the railroad had on two towns in central Virginia:

Charlottesville and Scottsville are communities in the central Virginia Piedmont region. Charlottesville, the older one, was founded in 1744 as the courthouse town for Albemarle County. Twenty miles south on the James River, Scottsville was founded in 1818 as a port on the James River and the Kanawha Canal.

Even after the opening of the University of Virginia at Charlottesville in 1825, Charlottesville remained a dusty little village. Scottsville grew rapidly after its founding. Farmers from the surrounding counties brought their tobacco and wheat to Scottsville to be shipped from there by canal boat down to Richmond. Soon Scottsville had a population twice that of Charlottesville. Scottsville was a bustling town with 21 stores; 24 shops of blacksmiths, canal boat builders and other tradesmen; three taverns; and four churches. For that era, Scottsville was a prosperous town.

Then, in 1850, the Virginia Central Railroad extended its tracks westward to Charlottesville. Two years later, the Orange and Alexandria Railroad arrived from the north. Since railroad locomotives were much faster than canal boats, Charlottesville soon replaced Scottsville as the commercial center for the region.

Today, Scottsville is a lovely, peaceful little village picturesquely nestled in the Albemarle hills on the banks of the James River. Charlottesville, on the other hand, is now a bustling center for education, commerce, and industry. The tale of these two Virginia cities illustrates how changes in transportation affect the destinies of cities.[1]

Procedure Discuss with the students the development and construction of the James River and Kanawha Canal and the purpose it was meant to serve. Ask them why they think a water transportation route was chosen as the link to the west rather than a road. What were the advantages to traveling by water and what were the disadvantages?

Discuss the advent of the railroads as a means of transporting goods and people. What were the advantages of railroads over the canal?

Have the students draw a time line to scale showing the development of both the canal and the railroads using information found in this guide, textbooks, and other sources. Ask them why the canal was not abandoned as soon as the first railroad tracks were laid in the state. Today, trucks carry many of the goods that were once transported by water and then by rail. Have the railroads also faced the same type of competition that they once gave the canal? What are the advantages and disadvantages of each of the three major modes of transportation that have been used over the past 200 years (water, rail, and highway)?

Next read or discuss the story of Charlottesville and Scottsville in the Background section above. Ask the students to write a series of short newspaper articles or headlines which focus on the fortunes of the two towns and their relationship to the James River and the railroad. They can write about the major highlights on the time line or any other time periods you or they choose.

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[1] *Virginia History and Government, 1850 to the Present*, Teacher's Edition (Silver Burdett Company, 1986) pp. T45-46.

Social Studies

SOL: 7.3, 8.10, 9.5

IIIf

Skills: using research and analysis, making inferences

IT'S A FACT -OR IS IT?

Objective The student will identify some reasons for inaccuracies and contradictions in historical information.

Methods Students will identify topics concerning the history of Belle Isle and the James River about which there are discrepancies in information. They will discuss reasons for the variations.

Background The HISTORY OF BELLE ISLE contained in this guide makes reference to several contradictions in information about the island's past. For example, there are ruins of a building constructed in 1777, which was supposedly a boarding house or hotel, but there are no records of a factory or other industry on the island that early which would require lodging for people.

In 1815, a snuff factory was built and various sources attribute it to either James Hume or James Bell. Then around 1827 the island was owned by General J. Harvie. Some sources say the J. stood for John and others say it was for Jacqueline. One source claims that Harvie ran a racetrack on the island and later rented the island to James Bell. Another says it was Bell who started the racetrack and that Bell bought the island.

Procedure Discrepancies such as those cited above are true not only of the history of Belle Isle, but of other historical accounts as well. For example, read the description of a trip taken on a Packet Boat in the activity called ROW YOUR BOAT. The trip supposedly took place in February and yet the canal was described as a ". . .ditch filled with slimy water, snakes, and bullfrogs, and fringed along its banks with lily pads and weeping willows. . . ." One generally doesn't find many snakes, bullfrogs, and lily pads in evidence in Virginia in midwinter! Perhaps the writer took several trips on such a boat and mixed the description of the scenery into one account.

Ask your students to brainstorm some possible reasons for differing accounts, dates, names, descriptions, etc. that are found in written and oral reports of historical events. Make a list of these reasons and then add some ways to narrow the possibilities to the one that is most likely to be correct. Can you ever be sure? Just because you see it written down somewhere doesn't necessarily mean it is true!

Have the students try to research some information themselves on Belle Isle and see if they find references to any of the above discrepancies or others.

The new Lee Bridge crosses Belle Isle at the point where the Civil War prison camp was located. What do you think the construction has done to possible artifacts of the camp? Again review the Background section of the ROW YOUR BOAT activity to find the reference to the discovery of canal boats during the excavation for the James River Center in downtown Richmond. In this case, work was halted for a few weeks when the canal boats were discovered so that a hurried archaeological dig could take place. Is this the best circumstance for such research? What might be some problems associated with such a dig? No artifacts were unearthed during the initial stages of construction for the new Lee Bridge. Does that mean that none were there? What is the likelihood that any would be found now? Why or why not?

In the years since Belle Isle became part of the James River Park, there have been problems with vandalism. For example, the 1777 house remained fairly intact until it burned in the early 1980's. Most fires on Belle Isle since 1972 have been the work of arsonists or vagrants and putting them out quickly is nearly impossible because there are no longer any intact bridges to the island. What damage has been done to any possible historical research efforts by these fires and other vandalism? How could such problems be prevented in the future?

To illustrate the problems inherent in human communication, play the "telephone game" with your students. Make up a message which contains a few names, dates, and some factual information similar to that found in the HISTORY OF BELLE ISLE. Whisper the message to one person in the class. Ask that person to convey the message to someone else, and so on until everyone in the room has heard and relayed the information. Ask the last person to tell the group what he or she heard and compare it with the original information. Generally there will be at least a few discrepancies between the two passages and sometimes they will be vastly different. Ask the students to compare this process to that which takes place when historical accounts are recorded by people who were not actually present at an event. (You can also discuss the fact that even two eyewitnesses to an event often give different accounts of what happened, depending upon their perspective, point of view, bias, and the amount of excitement or confusion of the situation.)

DIVIDE AND CONQUER

Science and Social Studies

SOL:
Science 4.5, 4.12, 6.2, 6.17, 6.20, 9.9, 9.10
Social Studies 4.2, 4.3, 9.1, 9.2, 9.3

Ia, Ic, IIb

Skills: observing, using maps, interpreting models, making inferences

Objective The student will (1) give a general description of the terms "watershed" and "divide," and (2) identify the general location of the James River basin on a map of Virginia.

Methods Students will create their own miniature watershed to help them learn the meaning of the terms "divide" and "watershed."

Background The "watershed" or drainage basin of a river includes all of the land whose rainfall runs into the river either directly or indirectly through the tributaries of the river. A "divide" is an imaginary line along the ridge or "high land" which separates one river valley from another.

Watersheds and divides can refer to huge areas of land or to much smaller regions. For example, the Continental Divide of the United States is in the Rocky Mountains. All of the rainwater falling on the west side of the divide flows into the Pacific Ocean and all of that falling on the east side of the divide eventually flows into the Atlantic Ocean. The largest single watershed in the United States is that of the Mississippi River which includes all of the land between the Rocky Mountains and the Appalachian Mountains. You can also use the term watershed to describe the area drained by a single small stream or creek which is within the total watershed of a larger stream or river.

The James River is one of the longest rivers in the United States that is confined entirely within the boundaries of one state. The total watershed of the river covers more than 10,000 square miles. The river itself is 330 miles long stretching from the western border of Virginia to the Chesapeake Bay on the east. Along with the Potomac, the Rappahannock, and the York Rivers, the James is one of the major tributaries of the Chesapeake Bay from Virginia and it flows into the Bay at Hampton Roads. The James below Richmond is tidal and changes from fresh water upstream to a greater and greater salt content the closer it gets to the Bay.

Pollutants entering the James affect the drinking water supplies of cities such as Lynchburg and Richmond. The cities themselves create both point source (coming from a single place such as a discharge pipe) and non-point (from a wide area) pollution for the river. Point source pollution comes from industries, sewage treatment plants, and other easily identifiable locations. Non-point pollution is a result of harmful substances such as excess lawn fertilizer, automobile oil, ice and snow chemicals, etc. washing off streets and parking lots and into city storm sewers, which flow into the river. Other non-point sources of pollution are soil and chemical erosion from forests, farmland, and construction sites. Pollutants such as these have a great impact on fish, crabs, oysters, and other aquatic organisms both in the James and at Hampton Roads.

It is important to know the drainage basin of any body of water so that sources of problems such as soil erosion and pollutants which affect water quality can be more easily identified.

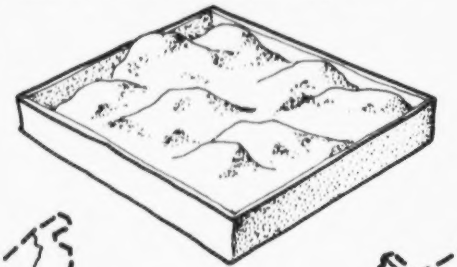
Materials Aluminum foil, small boxes, sprinkling can or similar device, water, large shallow box (such as a shirt box) lined with foil or plastic to make it waterproof, map of the James River basin in Virginia, food coloring.

Procedure Use the large shallow box lined with foil as a base container. Crinkle a large piece of aluminum foil and put small boxes or blocks under it in various places to create an artificial landscape with hills, ridges, and valleys inside the large shallow box.

Sprinkle water over the foil and observe the direction it flows. Identify divides and drainage patterns in your miniature landscape.

Put a few drops of food coloring in one place on your foil to simulate a pollutant. Now sprinkle water over the foil again and observe where the food coloring ends up.

Ask the students how this artificial landscape is different from or similar to a real land surface. Point out that real soil absorbs some rainwater (especially if it is



THE STORY OF A WATERSHED

covered with vegetation and is not highly compacted), so all rainwater does not run off as in this simulation.

Use the map of the James River basin to identify the boundaries of its watershed. Help the students see how much of Virginia the James' watershed covers.

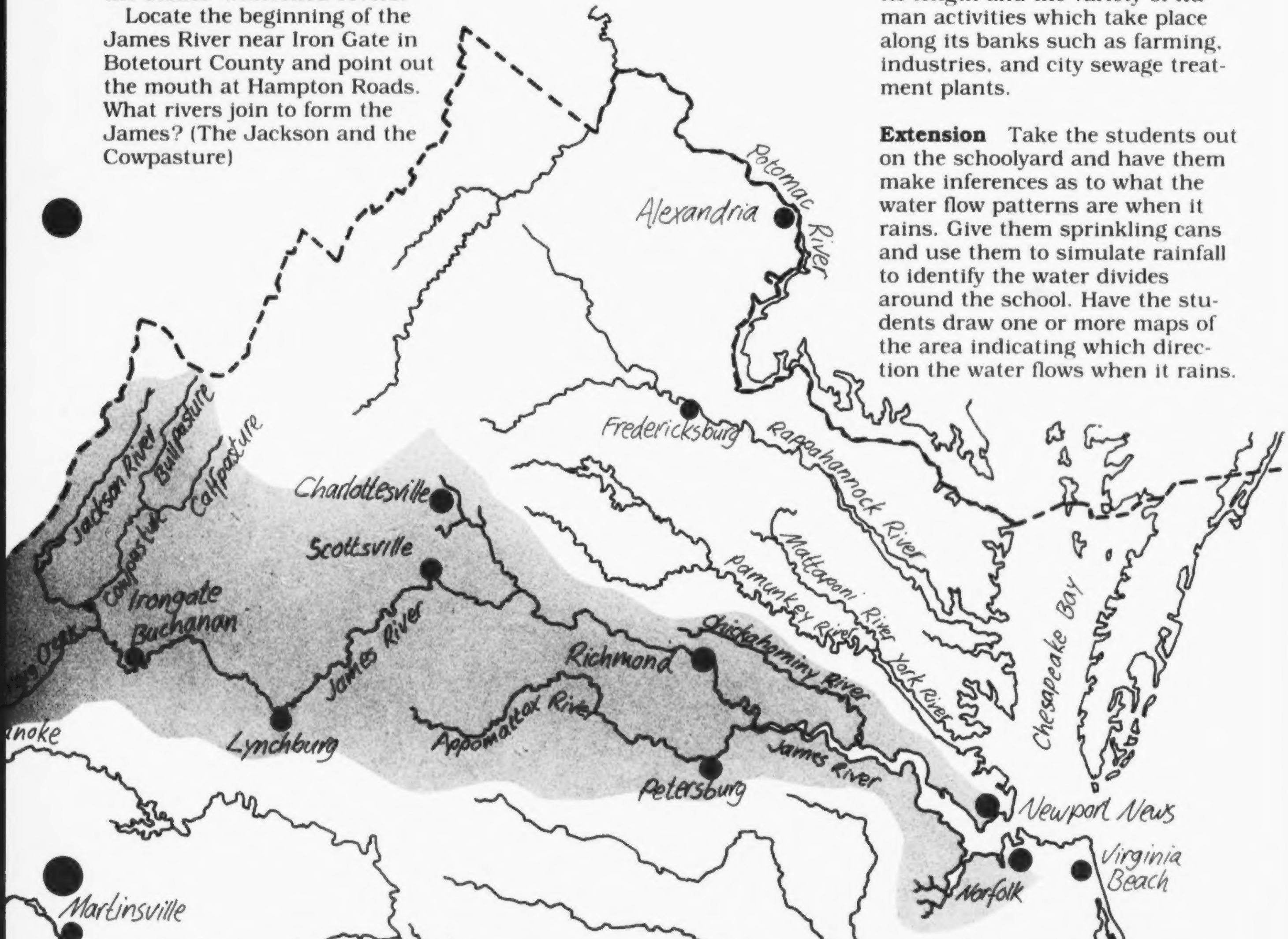
Locate the beginning of the James River near Iron Gate in Botetourt County and point out the mouth at Hampton Roads. What rivers join to form the James? (The Jackson and the Cowpasture)

Discuss the fact that the James is one of the major tributaries of the Chesapeake Bay and that it therefore has a great impact on the Bay at Hampton Roads. Locate the other major Virginia rivers which flow into the Bay.

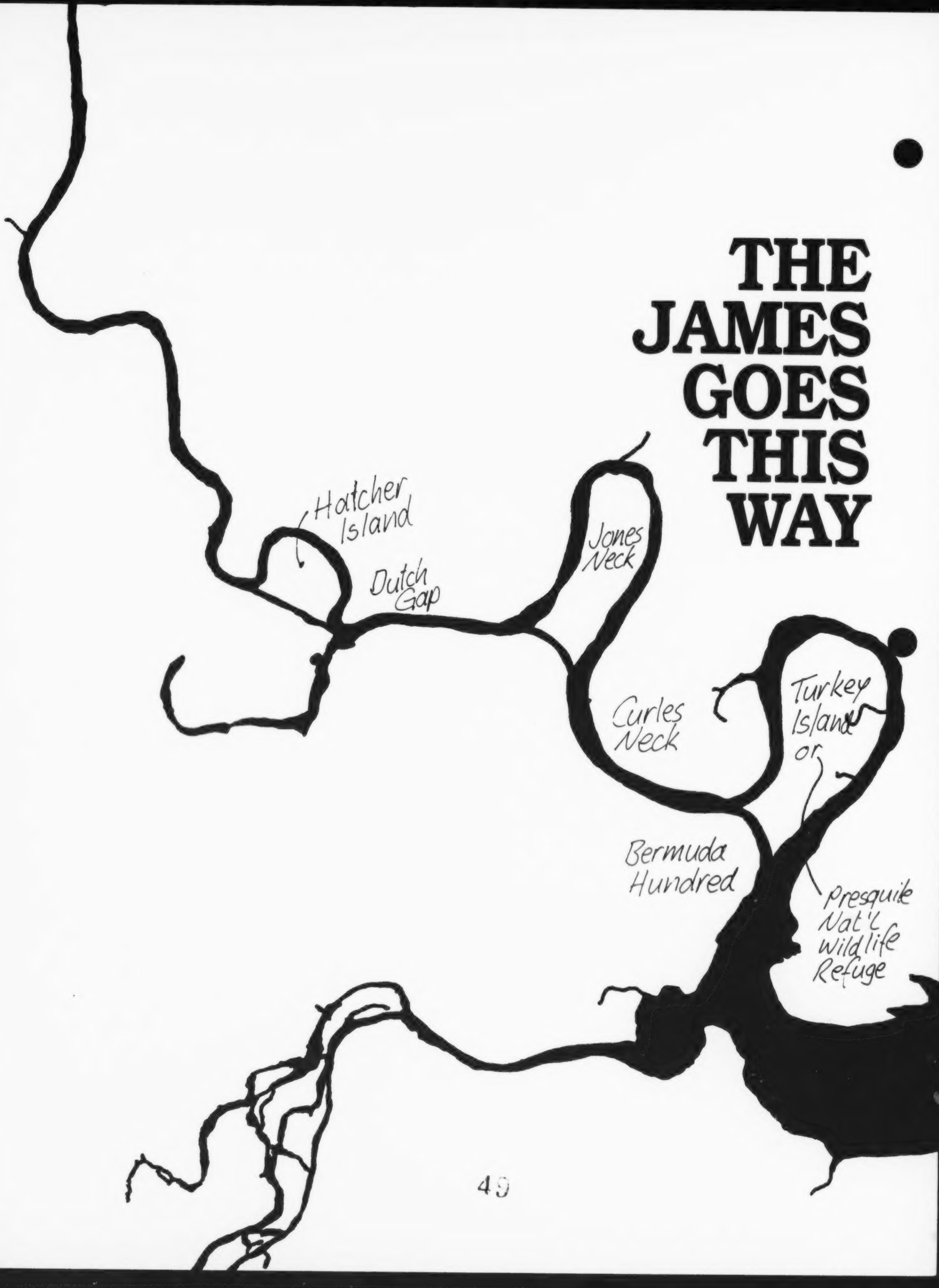
Identify and locate the major cities along the James. What kinds of pollutants (both point and non-point) might enter the river as it travels through a large city?

Discuss possible sources of pollutants in the James considering its length and the variety of human activities which take place along its banks such as farming, industries, and city sewage treatment plants.

Extension Take the students out on the schoolyard and have them make inferences as to what the water flow patterns are when it rains. Give them sprinkling cans and use them to simulate rainfall to identify the water divides around the school. Have the students draw one or more maps of the area indicating which direction the water flows when it rains.


Potomac River
Alexandria
Fredericksburg
Rappahannock River
Bullpasture
Calfpasture
Jackson River
Cowpasture
Charlottesville
Scottsville
Mattaponi River
Pamunkey River
Chickahominy River
York River
Chesapeake Bay
Cowpasture
Irongate
Buchanan
ga Creek
James River
Richmond
Appomattox River
Lynchburg
James River
Petersburg
noke
Newport News
Virginia Beach
Norfolk
Martinsville
Danville
Dan River

THE JAMES GOES THIS WAY


Hatcher Island
Dutch Gap
Jones Neck
Curles Neck
Turkey Island or
Bermuda Hundred
Presquile Nat'L Wildlife Refuge

Science

SOL: 4.12, 6.2, 6.20, 9.2, 9.9, 9.10

Ia, Ic

Skills: observing, making inferences, measuring, interpreting models, predicting, gathering data

Objectives The student will (1) compare the characteristics of immature and mature rivers, (2) explain how rivers are formed, and (3) describe how running water causes erosion.

Methods Students will use a stream table to examine erosion, deposition, and transportation of sediments.

Background Rain that falls upon the earth's surface and does not evaporate or sink into the ground begins the process of soil erosion. If land is clear of vegetation, raindrops cause small bits of sand, silt and clay to break away from the surface soil. The water will move across the land as runoff, and as the rain continues, more and more particles break free.

Surface runoff forms flowing sheets of water that will collect in small channels. These channels will join together to form small streams which will come together to form rivers. The rate of erosion depends on the quantity of precipitation, amount of ground cover, and the slope of the land. Soil carried into a river or stream will be deposited on the bottom, generally wherever the velocity of the water decreases, such as on the inside of a bend or where the water moves over flat land.

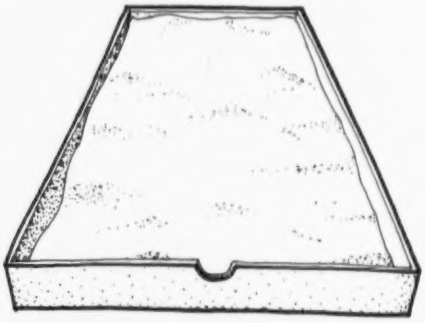
An immature river is characterized by V-shaped valleys, rapids and waterfalls. After many years of erosion, the valley floor will flatten and most of the large boulders and waterfalls disappear and long winding curves called meanders develop. Bends in rivers and creeks cause undercutting of banks on the outside of a bend, where the water moves the fastest. In some areas, sediments that are deposited eventually block a meander and create an oxbow lake.

Among the most interesting geological features of the James River are several oxbows. They are located in the coastal plain below the Fall Zone, where the river moves relatively slowly compared to its velocity in the mountains. The map in this activity shows Dutch Gap, Jones Neck, and Turkey Island (Presquile National Wildlife Refuge) which lie on the border between Chesterfield and Henrico Counties. Although rivers sometimes create their own cutoffs across the narrow neck of an oxbow, the channels that created the islands and Jones Neck were dug in 1930 by the U.S. Army Corps of Engineers to shorten the distance that ships had to travel up the river to the port of Richmond.

The shape of the river and the topography of the land in this area have been dramatically changed over the past 50 years as a result of digging and dredging for sand and gravel. The river has deposited these materials here over a period of thousands of years. River sand and gravel have been used as ingredients in cement blocks, pipe, and highway base materials from Richmond to Hampton Roads.

Materials stream table with opening for drainage at one end (or a large, flat box lined with plastic), sand and pebbles, bucket or jar to catch drainage water, water in a sprinkling can (or can with holes punched in the bottom), 2 wooden blocks.

Procedure Cover the stream table with a moist mixture of sand and pebbles, but leave the area at the bottom (the end with the drainage hole) empty. You can create some surface features such as hills and valleys if you choose.



Raise the top of the stream table using one block of wood to prop it up.

Simulate "rainfall" using the sprinkling can at the top of the stream table.

Observe and sketch the pattern of any streams that develop. After the water has drained out, sketch the position and shape of the streams. Note the position of the pebbles and sand grains in the stream beds, and the shape of deposits in the bare area at the bottom.

Smooth out the sand and pebbles again. Repeat the procedure using two blocks of wood to prop the top end higher. Ask students to predict what they think will happen if you pour water over the soil now. Water again and sketch the streams.

Compare the results of the erosion and deposition for the two slopes.

Smooth out the soil again and then make a meandering river channel in the center of the sand/gravel mixture in the stream table. Raise the top end of the stream table and simulate rainfall with the sprinkling can. Observe closely to see where the velocity of the "river" is the fastest. Where do the erosion and deposition occur?

Ask the students to look at the map of the James River in this activity and see if they can determine whether it is a mature or an immature river. Does it meander at one or more locations along its route? Are there oxbows anywhere along the river?

The shape of the James below Richmond has been drastically altered by man. All of the cutoffs across the narrow necks of land have been made by the U.S. Army Corps of Engineers. Why do you think these were made?

In the past 50 years there has been a great deal of mining for sand and gravel near the river below Richmond. Why do you think this is a good place for such operations?

Describe the topography of the areas near the headwaters and at the mouth of the James. What would you expect the river to look like in each of these locations?

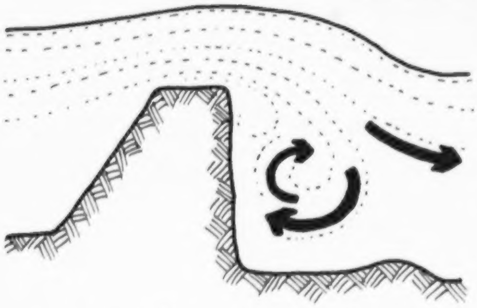
Science

SOL: 4.2, 4.3, 4.5, 4.6, 6.2, 6.3, 9.2, 9.4, 9.9

Ia, Ic, IIIg

Skills: observing, measuring, gathering data, predicting, making inferences

ROLLING DOWN THE RIVER



Hydraulic behind a dam

Objectives The student will (1) calculate stream velocity, and (2) identify the fastest and slowest currents in a stream.

Method Students will take a field trip to a stream or river and calculate the velocity of the water in various locations.

Background The velocity of a stream is determined mainly by the steepness of the stream bed or its *gradient*, with the water moving fastest where the bed has the greatest slope. Other factors which affect velocity are the amount of water passing a given point and the nature of the stream banks. Fast moving water has the ability to erode soil and rocks much more quickly than does slow moving water.

After it leaves the Blue Ridge Mountains, the James River is not very steep until it reaches Richmond. As it flows seven miles through Richmond, it drops 105 feet in elevation, causing the water to flow quickly over this stretch of the river. This seven mile area is called the *Fall Zone* by geologists (sometimes referred to as the Fall Line) and is noted for its white water rapids.

A river or stream running over a rough bed of rocks develops swirling, turbulent water in many places. Sand, pebbles, and small boulders get caught in natural cracks or depressions and over long periods of time the swirling water causes them to grind out oval or circular basins called potholes. (See the activity called POTHOLE PEEKING for more information and activity suggestions.)

Rocks, logs, dams and other obstructions affect the velocity and flow of the stream causing it to slow down in some places and to churn around and around vertically in what is called a *hydraulic* in other places (especially at the base of dams). These areas are extremely dangerous to swimmers and boaters who can get trapped by the tremendous force of the water in a large river such as the James, especially when the water level is high.

Boaters learn to "read" a rapid to identify the best path to travel through it. A smooth "tongue" of water often points out a good route. "Standing waves" are found just above rocks that are well submerged. "Hydraulics" are located behind (or downstream from) rocks that are just barely submerged. "Eddies" or pools are found behind larger rocks that are sticking up out of the water and are places where the water actually moves *upstream* for awhile.

Materials Each pair of students will need: a stick; 2–3 corks, styrofoam packing pieces or other small floating objects; string (1 meter long); stopwatch or watch with second timer

Procedure Go to a stream near your school or to an area along the James River where the students can safely move around among the rocks to investigate stream velocity. If you are going to the James River, call 804-226-4423 shortly before the trip to get a report on the water level as measured at the Westham gauge. If the water level is above 6.0 feet, it would be advisable to postpone your trip. Life jackets are recommended if you are taking students to the James River. They can be borrowed from the James River Park naturalist. Call 231-7411 for more information.

Have the students work in small groups and designate one student the "timer" and one the "dropper".

Tie one end of the string to one end of the stick. Tie a cork or piece of styrofoam to the free end of the string.

Give the "timer" a watch and the "dropper" the apparatus described above.

When the "timer" says "go", the "dropper" should drop the cork into the water and then hold the stick over the place where the cork went in. When the cork has floated downstream the full length of the string (or 1 meter), the "dropper" tells the "timer" to "stop". The team can then determine the velocity by noting the number of seconds it took for the cork to travel the 1 meter.

Ask each group of students to conduct this activity several times, recording their results (or the number of seconds) each time, and then calculate the average velocity. Have the groups move to different areas and decide where the fastest and the slowest sections of the stream are located.

Ask the students the following questions:

Why do you think some sections of the stream have a greater velocity than others?

Are there any places where the water seems to go around and around or to stand almost still rather than going downstream? If your answer is yes, why do you think this happens?

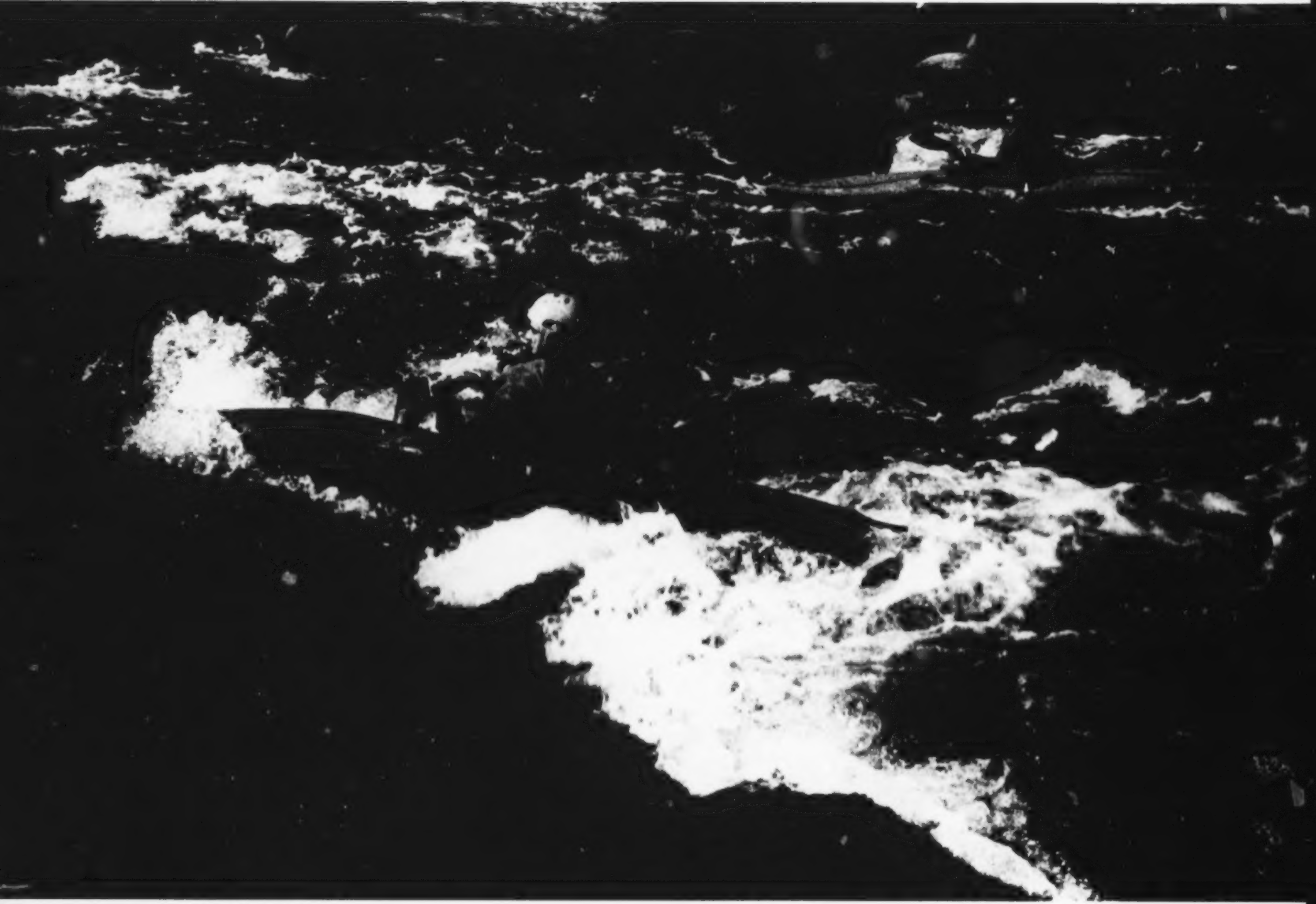
Do you think the water would be moving faster or slower if you did this activity when the stream was swollen with more water from a rain? Why do you think so?

In general, do you think the water in a river will flow faster as it comes down the side of a mountain or when it is traveling across a flat area of land? Why do you think so?

If you enjoy rafting, canoeing, or kayaking, where on the river would you be most likely to find white water or rapids for these sports? Read the description of how boaters "read" rapids in the Background section. See if you can identify any of these features in your section of the stream or river.

Extension Give the students corks or pieces of styrofoam. Have them write their initials or draw a picture on it with a waterproof magic marker. Locate a section of the stream with some obstacles such as rocks or logs. Mark a START and a FINISH line and have a race to see whose "boat" can complete the course the fastest (and not get stuck). Use a dip net or a similar device to retrieve the "boats" at the finish line.

Activity adapted from the "Great Streamboat Race", Outdoor Biology Instructional Strategies, Set I, Lawrence Hall of Science, University of California, Berkeley, 1975.



Science

SOL: 4.12. 4.15. 6.17. 6.20. 6.21

Ia. Ib. IIb. IIc. IVc

Skills: making inferences

ROUND AND ROUND AND ROUND IT GOES

Objectives The student will describe the water cycle and some of the natural processes which help clean water.

Method Students will read a story about the adventures of a water drop and answer questions, draw pictures, or act out a skit relating to the water cycle.

Background Approximately 71% of the earth's surface is covered with water. Although water molecules can be broken down into hydrogren and oxygen atoms by some natural processes, most of the water on earth has existed as water for a long time. It has been said that some of the molecules of water you used to brush your teeth this morning were probably once swallowed by a dinosaur. Water is also called the "fluid of life." Water makes up a major portion of all living things. About 65% of *your* body weight and 95% of a ripe tomato is water.

Water is continually recycled through the process of evaporation, condensation, and precipitation. Therefore, it is considered to be a renewable resource, or one that is not "used up". However, clean, fresh water which people and other animals need to drink for survival is not always plentiful. Although a great deal of the earth is covered with water, most of it is salt water in the oceans. Only 3% of the water on earth is fresh and 2% of that is locked in glaciers and the polar ice caps. Thus only 1% of the earth's water is available fresh water.

There is no such thing as a "universal" solvent, but a great many substances do dissolve in water, which is a blessing and curse at the same time. Human activities often add harmful chemicals and bacteria to our water which are not easily removed. Mother Nature can clean up some of the "stuff" in water through the processes of decomposition, settling, and filtering as water travels down a river and through marshes, the soil, and other natural filters. Unfortunately many man-made pollutants such as heavy metals, petroleum products and some chemicals which don't break down into harmless substances quickly are not always removed naturally.

People all along the James River use it as a source of drinking water (and also as a place to dispose of sewage). If one begins at its source in Botetourt County and travels downstream, the first major city on the river is Lynchburg. Approximately 100 miles downstream from Lynchburg is Richmond, and then 35 miles farther on is Hopewell. Finally, the James flows into the Chesapeake Bay and then the Atlantic Ocean.

Water supply problems are often considered to be local concerns. However, because the hydrologic cycle continually moves water from one place to another, and because a very small portion of the water on earth is fresh, water quality and supply are actually global problems and local water management practices can affect the planet as a whole.

Procedure Read aloud or have the students read the story of "Drip the Drop" and answer the questions relating to it.

FROM SEA TO SKY Far out at sea, somewhere near the horizon, John Q. "Drip" Waterdrop floated with his friends. Drip rolled over slowly in the sunlit ocean. The warmer he got, the harder it was for him to stay still.

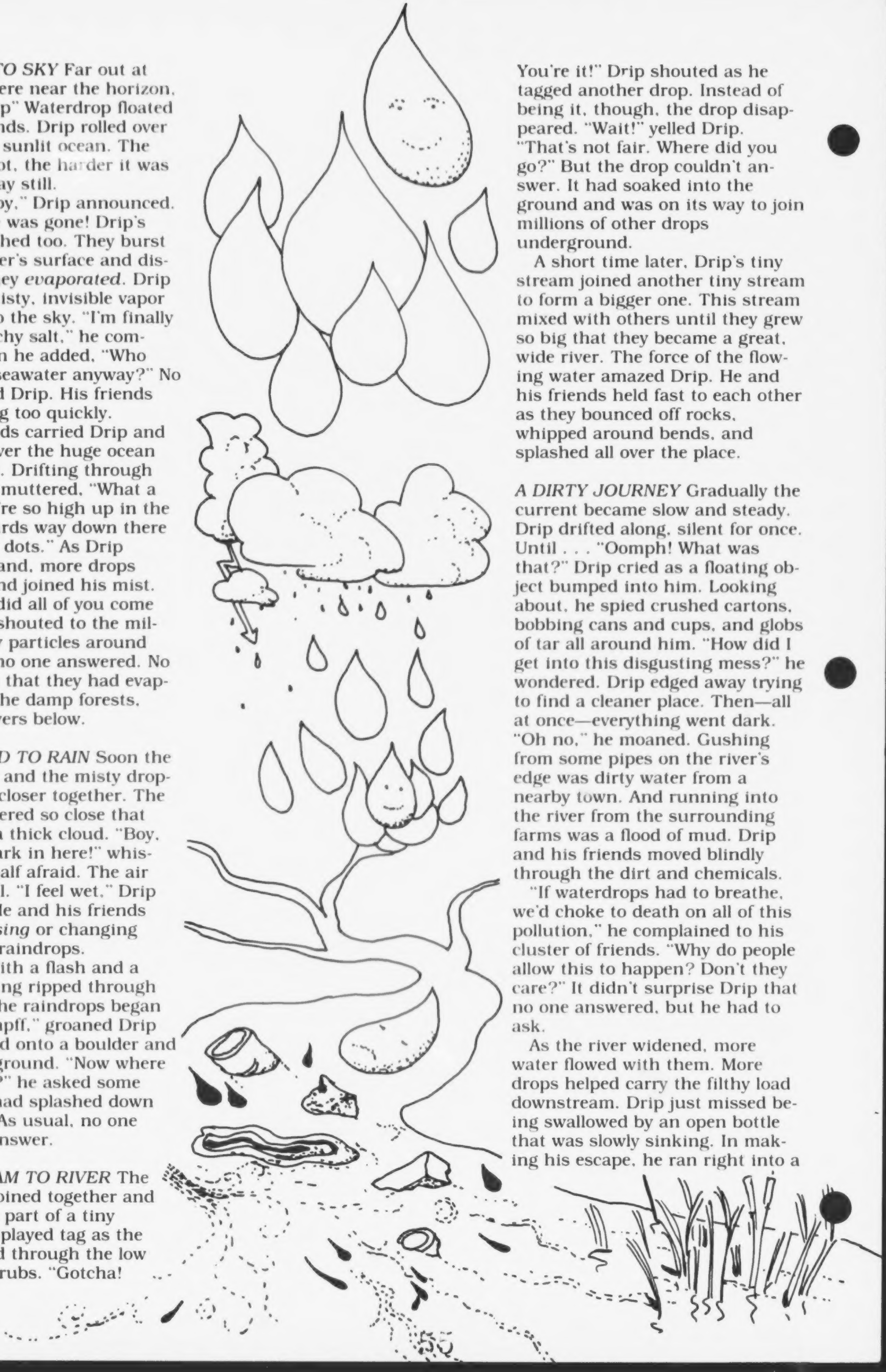
"I feel jumpy," Drip announced. Suddenly, he was gone! Drip's friends vanished too. They burst from the water's surface and disappeared. They *evaporated*. Drip was now a misty, invisible vapor floating up to the sky. "I'm finally rid of that itchy salt," he commented. Then he added, "Who wants to be seawater anyway?" No one answered Drip. His friends were all rising too quickly.

Steady winds carried Drip and his friends over the huge ocean toward shore. Drifting through the air, Drip muttered, "What a view! But we're so high up in the sky! Those birds way down there look like tiny dots." As Drip floated over land, more drops evaporated and joined his mist. "Hey, where did all of you come from?" Drip shouted to the millions of misty particles around him. Again, no one answered. No one told Drip that they had evaporated from the damp forests, lakes, and rivers below.

FROM CLOUD TO RAIN Soon the air got cooler and the misty droplets crowded closer together. The droplets gathered so close that they formed a thick cloud. "Boy, it's getting dark in here!" whispered Drip, half afraid. The air got cooler still. "I feel wet," Drip murmured. He and his friends were *condensing* or changing from mist to raindrops.

Kaboom! With a flash and a crash, lightning ripped through the clouds. The raindrops began falling. "Ummpff," groaned Drip as he splashed onto a boulder and rolled to the ground. "Now where are we going?" he asked some friends who had splashed down next to him. As usual, no one bothered to answer.

FROM STREAM TO RIVER The water drops joined together and sped along as part of a tiny stream. They played tag as the stream wound through the low weeds and shrubs. "Gotcha! You're it!" Drip shouted as he tagged another drop. Instead of being it, though, the drop disappeared. "Wait!" yelled Drip. "That's not fair. Where did you go?" But the drop couldn't answer. It had soaked into the ground and was on its way to join millions of other drops underground.

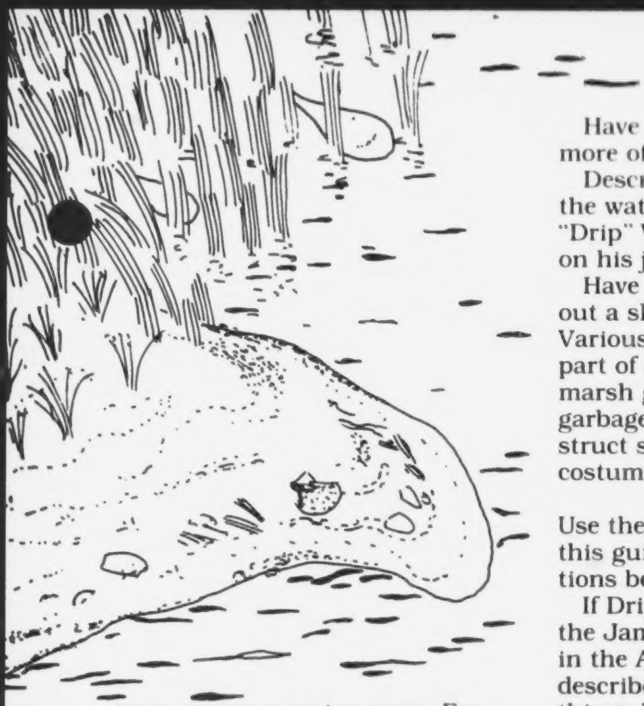


A short time later, Drip's tiny stream joined another tiny stream to form a bigger one. This stream mixed with others until they grew so big that they became a great, wide river. The force of the flowing water amazed Drip. He and his friends held fast to each other as they bounced off rocks, whipped around bends, and splashed all over the place.

A DIRTY JOURNEY Gradually the current became slow and steady. Drip drifted along, silent for once. Until . . . "Oomph! What was that?" Drip cried as a floating object bumped into him. Looking about, he spied crushed cartons, bobbing cans and cups, and globs of tar all around him. "How did I get into this disgusting mess?" he wondered. Drip edged away trying to find a cleaner place. Then—all at once—everything went dark. "Oh no," he moaned. Gushing from some pipes on the river's edge was dirty water from a nearby town. And running into the river from the surrounding farms was a flood of mud. Drip and his friends moved blindly through the dirt and chemicals.

"If waterdrops had to breathe, we'd choke to death on all of this pollution," he complained to his cluster of friends. "Why do people allow this to happen? Don't they care?" It didn't surprise Drip that no one answered, but he had to ask.

As the river widened, more water flowed with them. More drops helped carry the filthy load downstream. Drip just missed being swallowed by an open bottle that was slowly sinking. In making his escape, he ran right into a



large clump of water grass. Farther along, more grass, reeds, and other water plants spread out in a huge marshland. All the drops had to drift through it. When they emerged from the marsh, they were much cleaner! "Where did that disgusting junk go?" Drip asked. Then he realized that the leaves, stems, and roots of the plants had trapped much of the trash, dirt, and chemicals.

BACK AT SEA Drip and his friends passed out of the marsh and into a large bay. Just as he looked to the horizon, he noticed a funny taste. It seemed familiar. Then he remembered and understood. Drip had regained the salt he had shed at the beginning of the voyage.

"Well! What do you know! We're back where we started," Drip exclaimed as he and his friends rode the top of a big wave. "So", Drip couldn't resist asking, "where do you think the sun and wind will send us next?"

No one answered, but John Q. "Drip" Waterdrop didn't care. Wherever he went, he was sure to be part of a great adventure!

DRIP THE DROP, by Beth Wagner (from *Ranger Rick Magazine*, March 1983, Volume 17, Number 3, published by the National Wildlife Federation, 1412 16th Street, NW, Washington, D.C. 20036)

Have the students do one or more of the following activities:

Describe or draw the steps in the water cycle that John Q. "Drip" Waterdrop went through on his journey.

Have students develop and act out a skit based upon this story. Various students can take the part of other water drops, clouds, marsh grasses, pollutants and garbage. They can draw or construct scenery and props or costumes.

Use the map of the James River in this guide to answer the questions below:

If Drip's stream had flowed into the James River at its beginning in the Appalachian Mountains, describe some of the places and things he would have seen on his way back to the ocean.

If you live in the Richmond area and your water comes from the James River, identify some of the towns or cities that have used the water or added pollutants to it before it gets to you. About how far away from Richmond are some of those places on the river?

The city of Hopewell is located on the James River but takes its drinking water supply from the Appomattox River. Why do you think they draw water from the Appomattox rather than the James? (Hopewell is only 35 miles from Richmond and the river has not had enough opportunity to cleanse itself after leaving the Richmond sewage treatment plant and other point and non-point sources of pollution before it gets to Hopewell. Therefore the Appomattox is cleaner than the James in Hopewell. See the Background section above for more information about nature's cleansing abilities.)

What is one reason that marshes should not be filled in or destroyed? Are there any marshes on the James River? Where would you be most likely to find them?

Scientists have discovered that the plants and animals in the Chesapeake Bay are not as plentiful as they used to be. What do you think might be some of the reasons for the problems of the Bay?

Extension Show the students a 5-gallon aquarium or bucket filled with water. If this aquarium represented all of the water on earth, all but two cups would be salt water in the oceans. Of that two cups of fresh water, 1 1/2 cups would be frozen in the polar ice caps. The remaining 1/2 cup would represent all of the water in lakes, rivers, the atmosphere, and groundwater. Less than one drop of *that* would be all of the water in all of the rivers on earth.

Discuss the fragile nature of the supply of fresh water on earth and what a minute percentage of the water on earth it actually is. Discuss the fact that humans depend upon this supply of fresh water for survival. Close by emphasizing the importance of keeping the earth's waters clean and healthy.

Science

SOL: 4.2, 4.14, 5.16, 6.2, 6.3, 6.14, 6.16, 7.1, 7.4, 7.5, 7.10, 7.14, 7.15, 7.16

IVa, IVb, IVc

Skills: observing, making inferences, data gathering

CRITTER COLLECTING -EVERYTHING IN ITS PLACE

Objectives Students will (1) collect and observe organisms from a body of water, (2) describe the habitat in which each kind of organism was found, and (3) identify some adaptations which plants and animals have in order to live in different environments.

Methods Students will make several types of devices for collecting organisms in a stream or river and use them to gather specimens for study.

Background The river is home to thousands of species of wildlife. They range in size from the smallest microorganisms to birds, fish and mammals. The river itself can be considered one large *ecosystem* or community of organisms together with their environment. Within this ecosystem, each kind of plant or animal occupies a particular *habitat* or home.

Some organisms can be found living on the surface film of a body of water. Others live out in open water, on the bottom, or near the water's edge. In a river or stream, some organisms live in fast-moving water, while others can be found only in calm areas. Generally those that live in moving water must either be able to swim to keep from being washed continually downstream, or they must be able to hold on to the bottom, rocks or other organisms so they won't be swept away. Often organisms that live in the water are streamlined to make movement easier.

Generally water that is clean will support a wide variety of organisms even in a relatively small area. Polluted waters often have less oxygen for breathing; are cloudy or muddy, so visibility is reduced (and therefore the ability of some species to find a mate is lessened); and/or contain toxic chemicals which cause cataracts, cancerous growths, and other abnormalities on fish and other organisms. There are only a few organisms that can survive in polluted water, so the numbers and variety of organisms found can be an indicator of water quality.

Materials Specimen collecting devices (see the attached sheet for instructions for making your own), bug boxes and hand lenses**, white-bottomed containers (enamel pans are best, but styrofoam meat containers and cardboard milk containers cut in half lengthwise work also), buckets, identification guides (such as *Pond Life: a Guide to Common Plants and Animals of North American Ponds and Lakes*, Reid and Zim, Golden Press, New York).**

**These materials can be found in the kit of materials accompanying this guide located in the central office of your school division (Check with the Science Supervisor or Director of Instruction)

Procedure Make or have the students make the specimen collecting devices described in this activity (or use commercially available equipment).

Take the students to a shallow area of the James River or a stream close to your school. Divide them into small groups and give each group a specimen collecting device, a white-bottomed container, a bucket, and some bug boxes and hand lenses.

If you are going to the James River, call 804-226-4423 shortly before the trip to get a report on the water level as measured at the Westham gauge. If the water level is above 6.0 feet, it would be advisable to postpone your trip. Life jackets are recommended if you are taking students to the James River. They can be borrowed from the James River Park naturalist. Call 231-7411 for more information.

Show the students how to use their equipment. Ask them to gather as many different kinds of plants and animals as they can. You may want to station groups in different locations so that some will be collecting organisms from various positions of the stream — moving water, calm water, near the shore, deep pools, shallow areas, etc.

Have them put their finds in their white-bottomed containers, in bug boxes, or in the bucket, depending on the size and moving ability of the critters.

Ask the students to observe their organisms carefully with the hand lenses, using bug boxes for small animals.

Do not ask them to identify their organisms yet. Let them make up their own names for what they found or just give brief descriptions of the organisms.

Have them consider the following questions first in their small groups and then with the group as a whole.

How many different kinds of plants and animals did you find?

Which kind of plant and which kind of animal are most abundant?

Which plant and which animal are least abundant?

Describe the habitat in which you found each of your organisms (surface, open water, bottom, attached to a rock or plant stem, moving water, still water, etc.)

How do you think the animals move?

How does the plant or animal appear to be adapted to its habitat?

What other interesting things do you observe about your organisms?

Compare your organisms to those collected by other groups.

Are there any plants or animals which seem to live in only one kind of area?

Are there any plants or animals which seem to live in more than one area?

Do you think this part of the river or stream is fairly clean or fairly dirty based upon what you have found? Why do you think so?

Finally, have the students use identification guides to see if they can find the names of the organisms they have collected.

After returning to the classroom ask the students to make a chart of the plants and animals they found showing their preferred habitats.

SPECIMEN COLLECTING AND VIEWING DEVICES These are some devices which you or your students can make to collect plants and animals from a body of water.

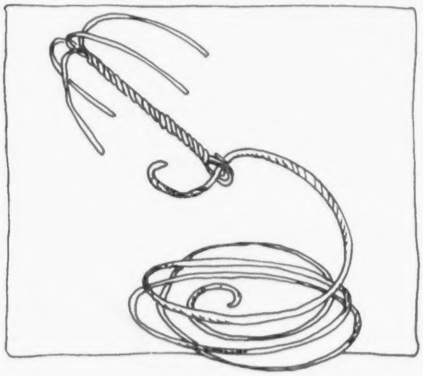
PLANT COLLECTOR

Heavy rope, 1 meter of barbed wire OR 3-4 pieces of heavy wire such as coat hanger wire.

Connect the ends of the barbed wire by twisting them around each other or bend the coat-hanger wire into hooks as illustrated. Tie one end of the rope to the wire.

To use, drop the plant collector into the water and pull it slowly with the rope to shore.

In addition to examining the plants themselves, look through the plants to see if there are any animals living there.



STOCKING NET

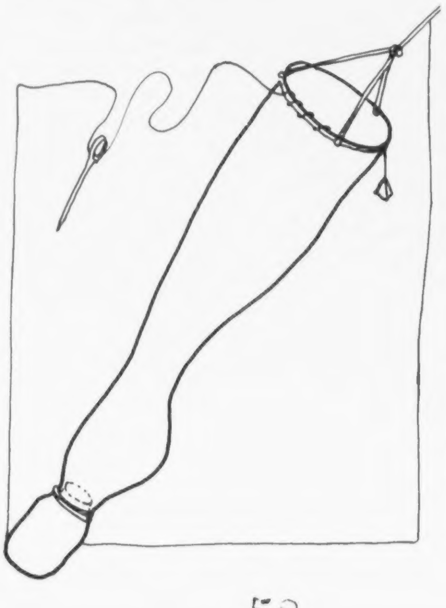
Wire ring (either coat hanger wire or a wire embroidery hoop), nylon stocking, clear plastic vial (such as a pill bottle), rubber band, lightweight rope.

Sew the top of the stocking to the coat hanger wire or put the embroidery hoop on it.

Drop the plastic vial into the toe of the stocking and secure it with the rubber band.

Attach the rope to the wire end of the stocking

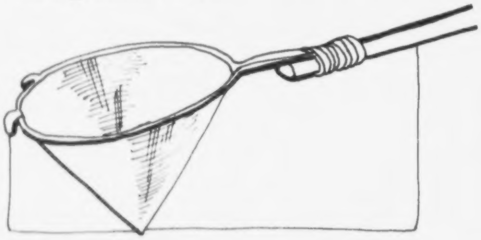
To use, hold the net in the current or tow it through the water. It may be necessary to tie a small weight to the wire end to help hold it down.



DIP NET

Large kitchen strainer, large dowel rod or broom handle, cord or tape.

The strainer can be used alone or can be tied or taped to the dowel rod or broom handle to provide greater reach.

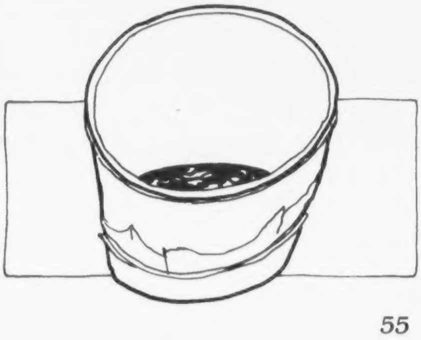


WATER SCOPE

Large can (such as a coffee can) with both ends cut out, clear plastic wrap, large rubber bands.

Place the plastic wrap over one end of the can and secure it with a rubber band.

To use, place the plastic covered end in the water and look into the other end for a better view of shallow water organisms.



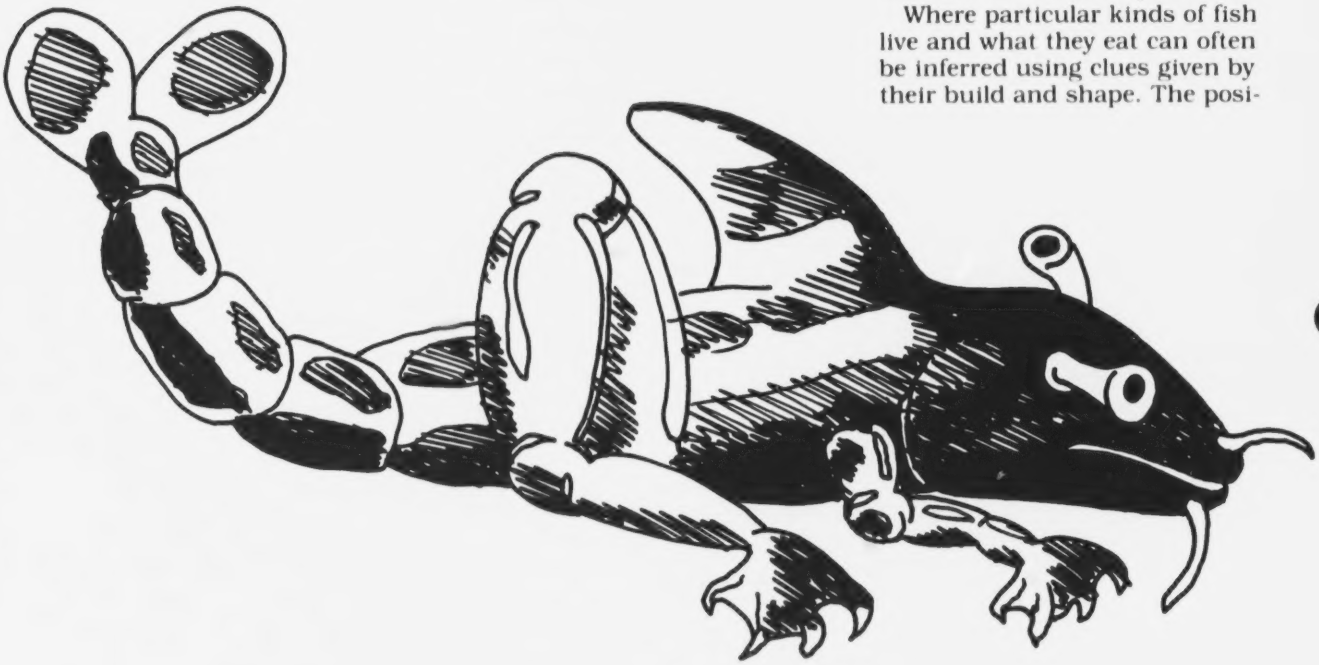
Science

SOL: 4.2, 4.14, 5.16, 6.2, 6.14, 6.16, 7.1, 7.16, 7.20

IVa, IVc

Skills: observing, making inferences

CRAZY CRITTERS



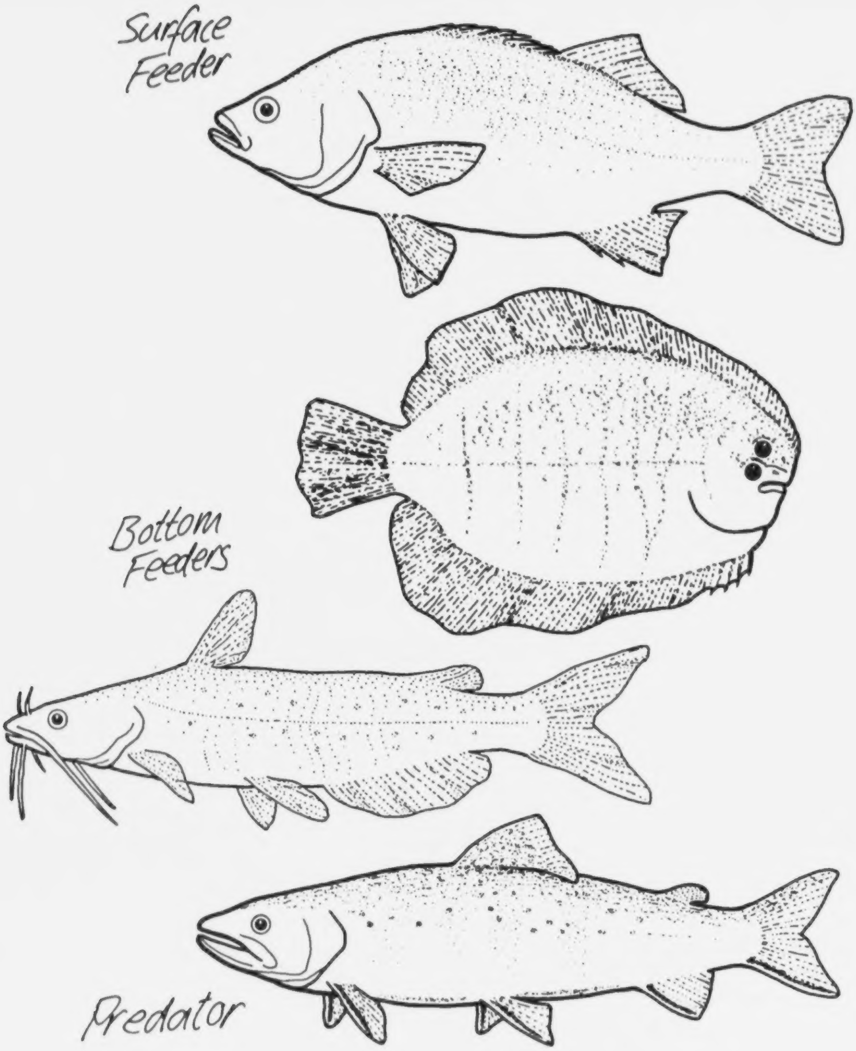
Objectives The student will describe some adaptations that aquatic animals have to help them survive.

Method Students will use art materials to draw or construct an imaginary plant or animal which could survive in an aquatic habitat of the student's choice.

Background An *adaptation* is any special feature of an organism which helps it survive or reproduce. Aquatic animals have adapted to their environment in various ways. For example, most fish have streamlined bodies so they can move through the water with as little effort as possible. Frogs are able to jump and move quickly and have long, sticky tongues which can spring out to catch insects. Crayfish and crabs have large pincers to hold and tear their food. Water striders have very long legs which enable them to skim across the surface of the water to catch other insects on or just below the surface. Clams and mussels have tubes to siphon food from the water. They also have a foot which they use to dig down into the mud to hibernate during winter. Caddisfly larvae build themselves a case of leaves, sand grains, twigs, or other debris for protection. Another typical adaptation is that many aquatic animals lay hundreds or thousands of eggs. The vast majority of eggs are consumed by predators or die naturally, but there are so many that at least a few survive to maturity.

Where particular kinds of fish live and what they eat can often be inferred using clues given by their build and shape. The position of the mouth and the type of teeth are good indicators of feeding habits. For example, bottom dwelling fish usually have mouths near the bottom of their head and they usually eat plant matter or decaying organic material typically found in the sediments. Fish with upward pointing mouths and sharp teeth usually feed on other animals near the water's surface.

Besides feeding adaptations, fish have developed other special features that help them avoid being eaten by predators. Many have markings and colorations on their skin that allow them to blend in



with their habitat. Some can even change color to match changing surroundings. This *camouflage* helps keep them hidden from predators. Other fish have a flat shape, which allows them to settle on the bottom, nestling unobtrusively in the sand. With only eyes showing, they are well hidden from the watchful gaze of hungry predators.

Plants also have adaptations which enable them to live successfully in or near water. Water lilies, bladderworts, cattails, and pitcher plants are a few examples of highly adapted water plants.

Adaptations can be structural (such as body shape or appendages), or they can be behavioral, as when an animal "freezes" or runs to escape detection or capture by a predator.

Information taken from the National Wildlife Week Education Packet "We Care about Oceans", National Wildlife Federation, 1412 16th St. NW, Washington, D.C., 20036, March 1981

Materials identification guides*, art materials such as paper, crayons, magic markers, paint, clay, pipe cleaners, construction paper, glue, cotton balls, straws, etc.

**Pond Life: A Guide to Common Plants and Animals of North American Ponds and Lakes*, Reid and Zim, Golden Press, N.Y. Copies of this guide can be found in the kit of materials accompanying this guide which is located in your school division central office.

Procedure Introduce the students to the concept of *adaptation* by investigating a number of plants and animals that live in or close to the river. Use the ones mentioned in the Background section above and supplement with others found in library books or identification guides.

Discuss the reasons for adaptations in plants and animals and the variety of ways various organisms protect themselves, find food, and reproduce.

After the students are familiar with this concept, ask them to "create" a critter or plant either by drawing it or constructing it out of the art materials provided. Before starting to design their organism, each student should decide:

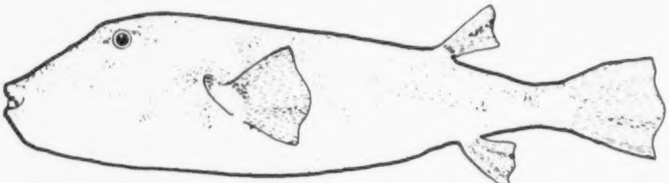
- where it will live
- what it will eat (if it is an animal or a carnivorous plant)
- how it will protect itself from enemies
- how it will move (or keep from moving if it lives in the current and doesn't want to be washed downstream)
- how it will reproduce.

Be sure to tell the students that their organism can be purely imaginary and does not need to resemble a real plant or animal in any way (for example, a critter might have x-ray vision to see through rocks and muddy water to detect enemies . . .)

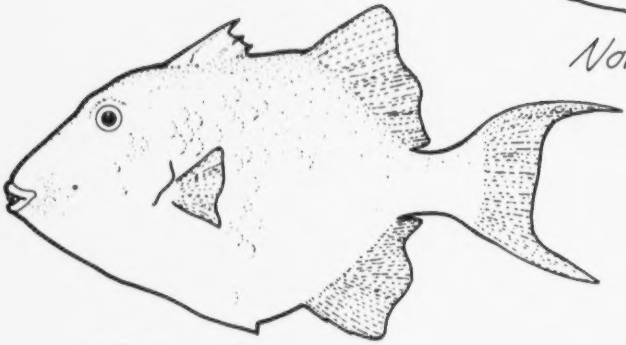
After their masterpieces are completed, ask the students to make up a name for their creation and write a brief description of its features and behaviors (just in case they are not obvious to someone with less imagination than the creator!).

Extension Many plants and animals that live in fast current have special adaptations for holding on and thus are prevented from washing downstream.

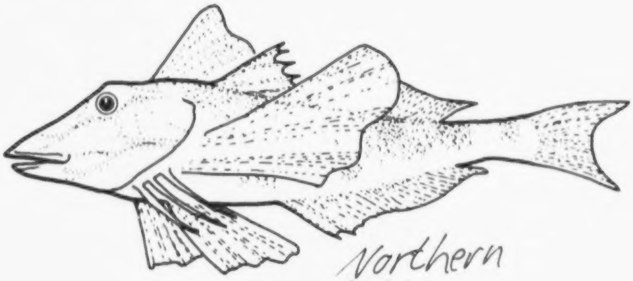
Using the materials listed above or others available, ask students to construct an imaginary creature that can "hold on" or in some way prevent itself from being washed away with the current. Take the creations to a stream or the river and test their "adaptations" to see how successful they would be. (Take along a dip net or other means of catching those that are unsuccessful at first so that the creator can have another chance to design a better critter . . .)



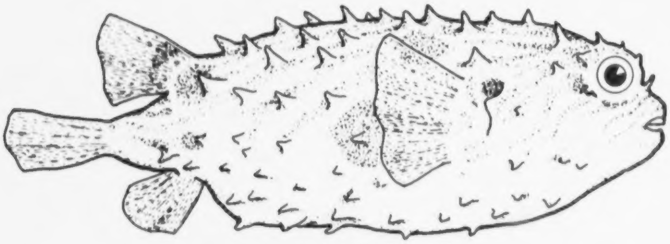
Northern Puffer



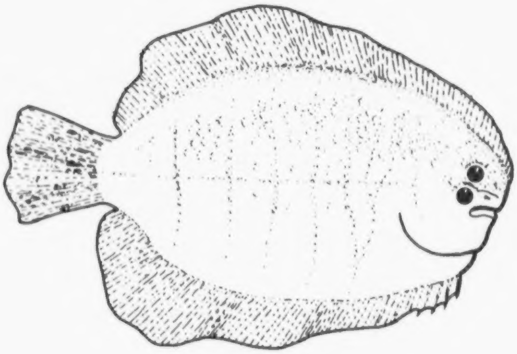
Grey Triggerfish



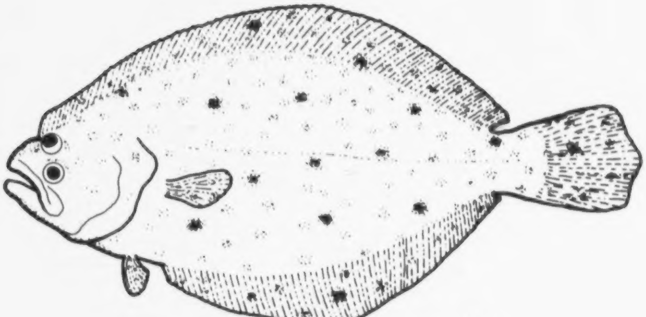
Northern Sea Robin



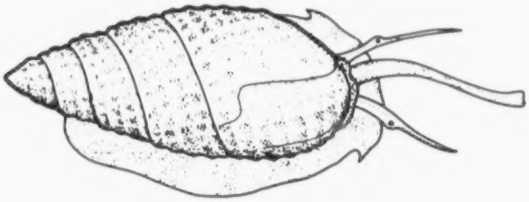
Striped Burrfish



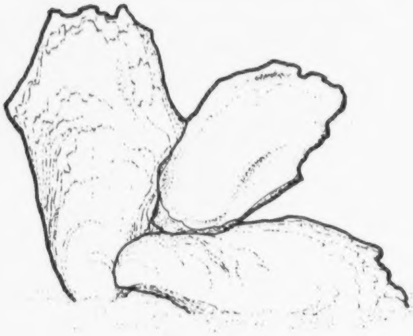
Hogchoker



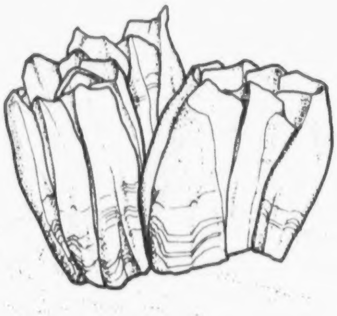
Summer Flounder



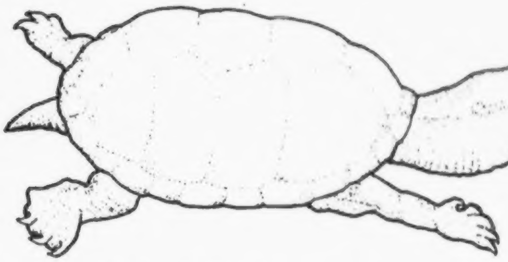
Mud Snail



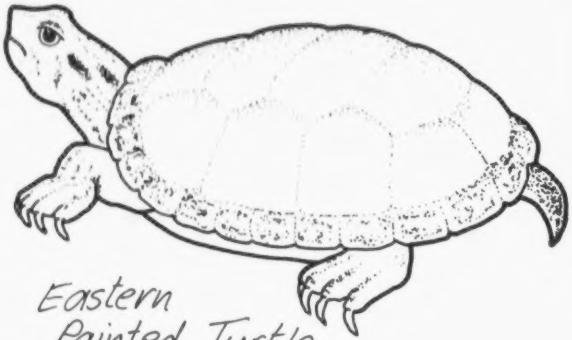
Oyster



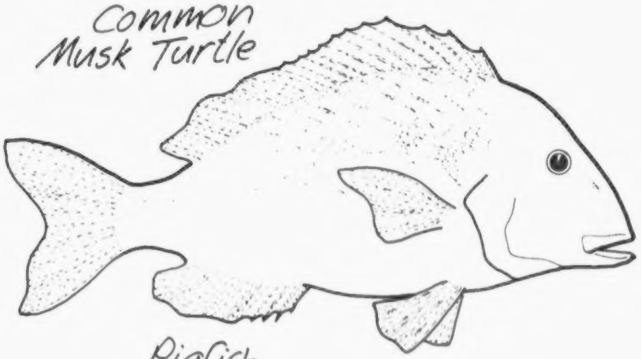
Acorn Barnacles



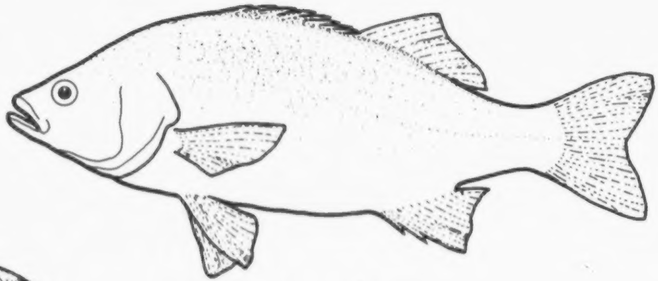
Common Musk Turtle



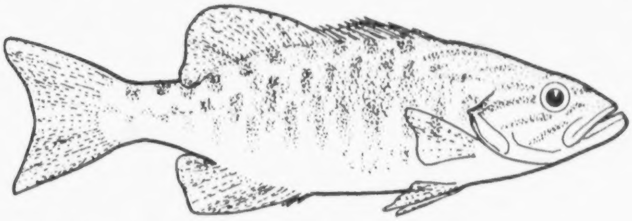
Eastern Painted Turtle



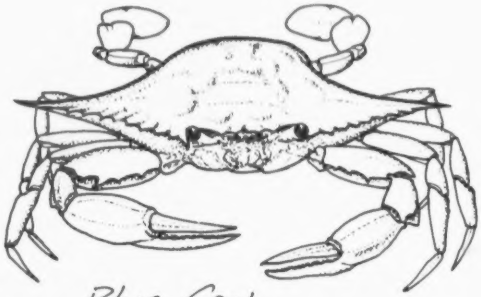
Pigfish



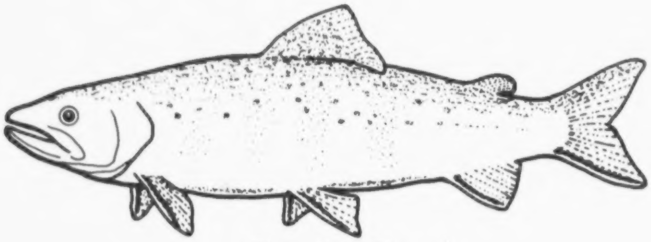
White Perch



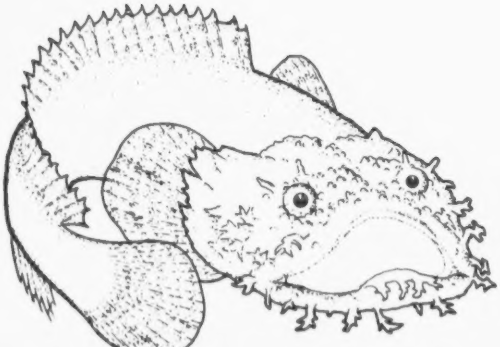
Smallmouth Bass



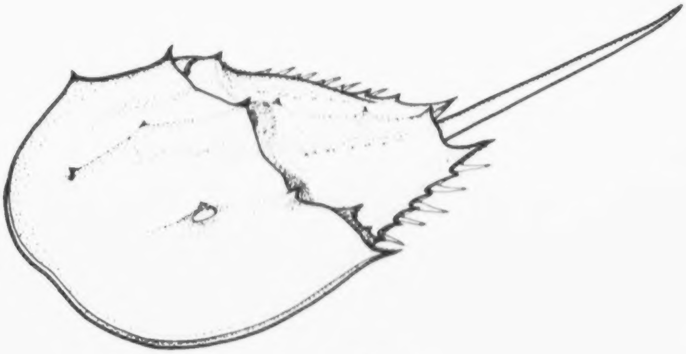
Blue Crab



Brook Trout



Oyster Toadfish



Horseshoe Crab

Science and Social Studies

SOL:
Science 9.2, 9.10
Social Studies 7.1, 7.4, 9.1, 9.2, 9.3, 9.8

Ic, IIIe, IIIf, IIIg

Skills: interpreting maps, making inferences, interpreting models

BELLE'S PROFILE

Objectives The student will (1) construct a profile using topographic contours, (2) explain why profiles are helpful in map reading, and (3) use the profile to make inferences about past and possible uses of Belle Isle.

Method Students will use a cross section line drawn on a topographic map and transpose data onto a Profile Sheet. This profile will be used to answer questions and make inferences about past and possible uses of Belle Isle.

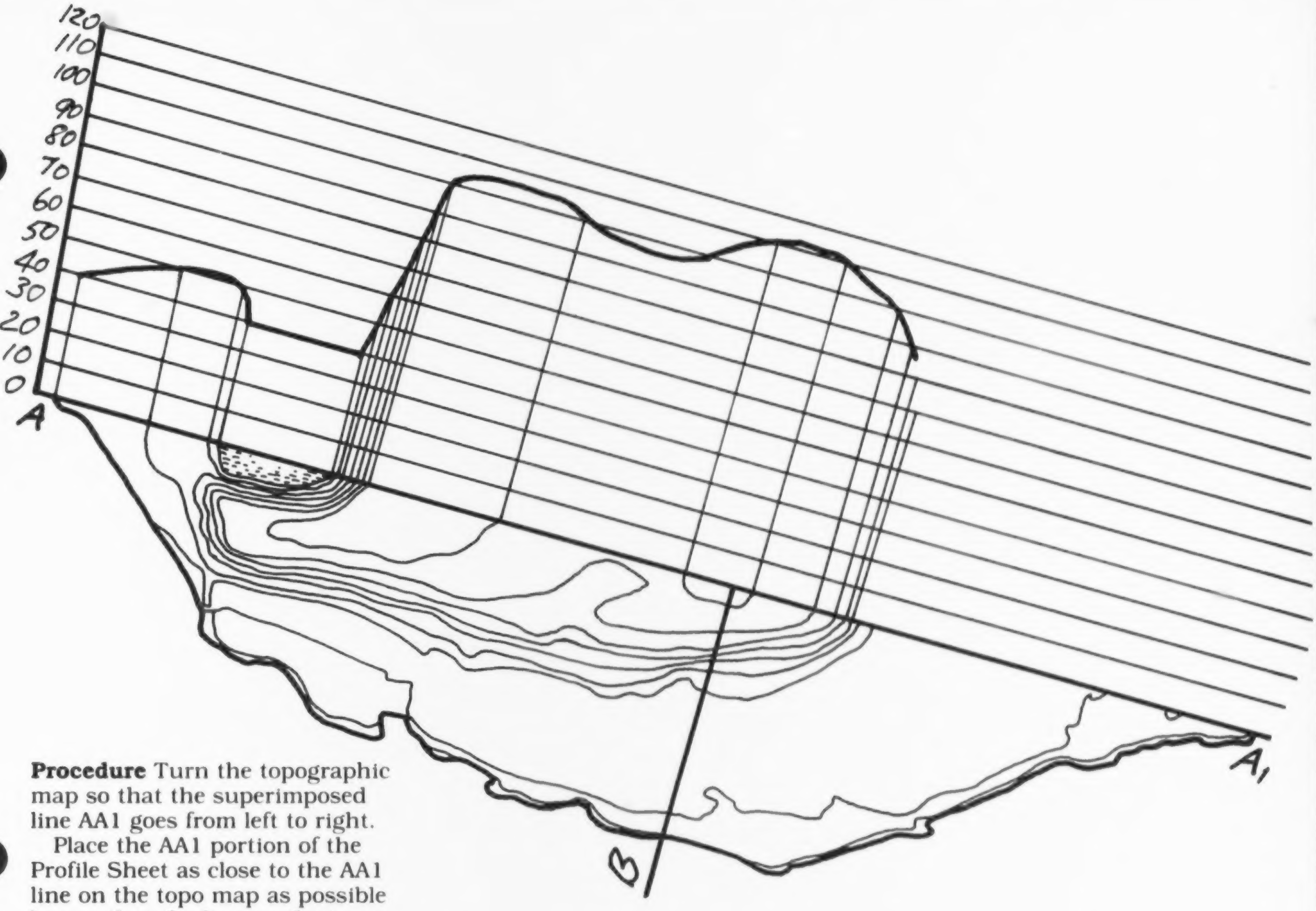
Background Topographic maps show accurate configurations of the land's surface and the size and shape of hills, valleys, plains and plateaus. They also show the location of these features with respect to each other.

Topographic maps have many uses as fundamental tools for planning and executing projects that are necessary for modern ways of life. They are of prime importance in planning airports, highways, dams, pipelines, industrial plants and countless other types of construction. Topographic maps are essential for studies about the quantity and quality of water. They greatly facilitate the study and application of flood control and soil conservation.

Belle Isle has been used for a variety of purposes in the past 300 years. In the late 1800's and early 1900's granite was quarried on the western end of the island and used for building foundations all over Richmond and for a dam which funneled water to the power plant located on the island. The area of the old quarry is now filled with water, but human activity here significantly changed the original topography of this part of the island.

A number of other industries besides quarrying have been located on the island over the years—from a water powered iron mill to a Virginia Power electric generating plant and a more modern Old Dominion Iron and Steel Works. Most of these industries were located on Belle Isle to take advantage of the running water to power their machines. Old Dominion Iron and Steel, a few of whose buildings can still be seen on the eastern end of the island, relocated after the flood accompanying Hurricane Agnes in 1972. Belle Isle is now part of the James River Park and plans are underway to make it an environmental study area. (See the HISTORY OF BELLE ISLE in this guide for more information about the island.)

Materials Topographic map of Belle Isle, Profile Sheet



Procedure Turn the topographic map so that the superimposed line AA1 goes from left to right.

Place the AA1 portion of the Profile Sheet as close to the AA1 line on the topo map as possible but so that the line on the topo map is still visible.

On the Profile Sheet, mark a dot on the corresponding elevation line straight below the point where the contour line intersects line AA1 on the topo map. Begin at the first contour line on the left and work toward the right until all contour lines have been marked by a dot on the Profile Sheet. When complete, there should be a series of dots on the elevation lines for every place a contour line intersects line AA1 on the topo map.

Connect the dots with a smooth curved line to represent the various elevations of the land so that it appears in vertical profile as you would see it if you were standing beside the island itself.

Repeat this procedure using line BB1 and again using another profile line which you draw on the topo map at any location you choose.

Old Dominion Iron and Steel Works (formerly located on the eastern end of the island) moved to a new location in Chesterfield County after Hurricane Agnes in 1972. Why do you think the industry was located here in the first place? (The water provided relatively cheap, abundant energy.)

What disadvantages did industries on the island have to contend with? (Access to the island for workers was via bridges or ferries, which were affected by high water with bridges and docks often being heavily damaged or washed away during floods. Also there was the periodic threat of flood waters reaching the factory buildings themselves.)

In the late 1800's and early 1900's granite was quarried from the western portion of the island. Water now fills the old rock quarry and it is shown on your topo map. Draw a profile and/or a topographic map showing what you think the western end of the island through line AA1 looked like *before* so much of the granite was removed. In what other ways and for what other purposes do humans change the topography of the land?

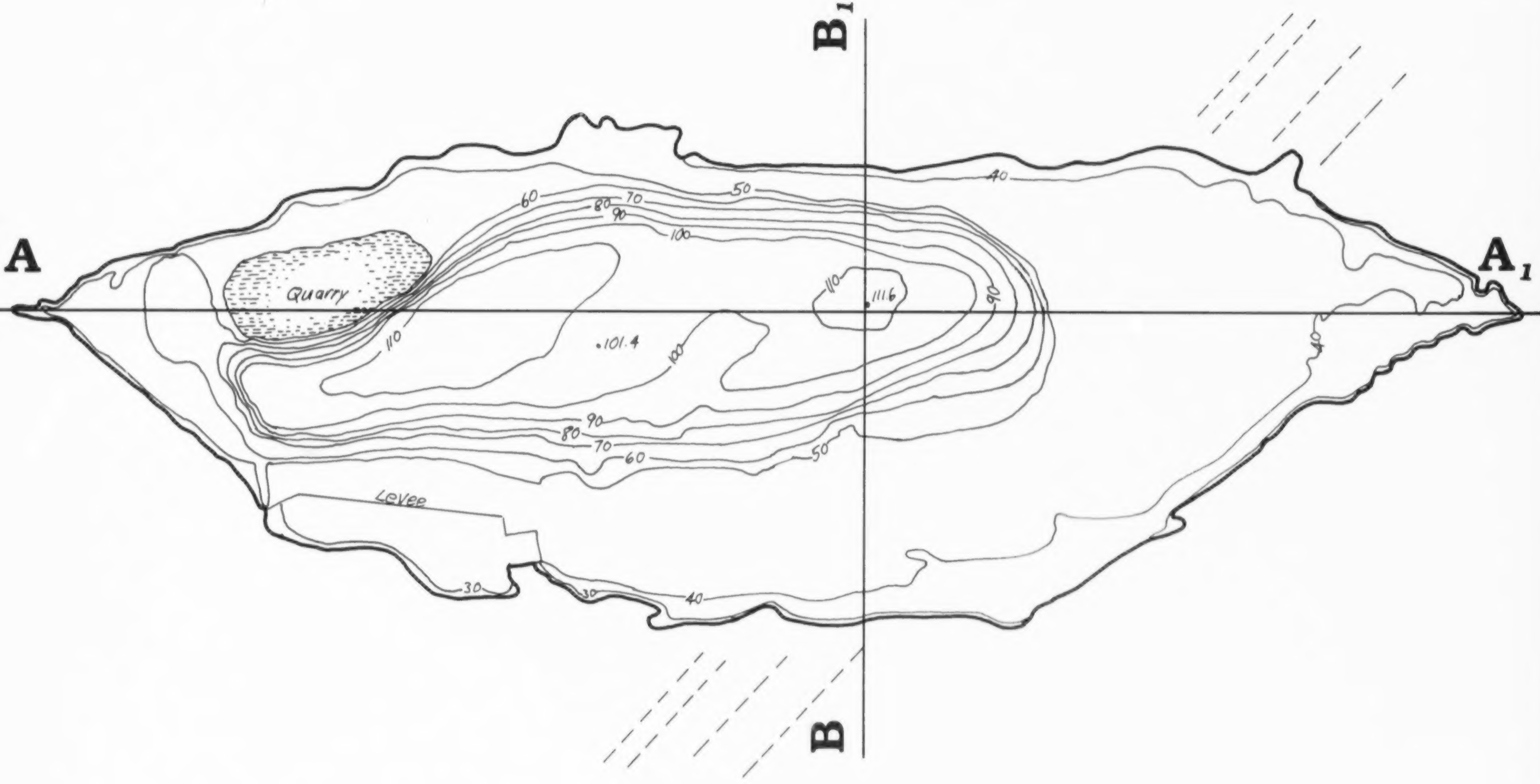
For what purposes do you think people use topographic maps?

Why are topographic map reading skills useful?

What is the value of drawing profiles of topographically mapped regions?

Extension Pretend you are a naturalist in James River Park. Design a sign or a brochure describing the topographic features of Belle Isle for visitors.

The city of Richmond plans to use Belle Isle for an environmental study area in the future. Use the topographic map and decide (a) what features should be part of this plan, (b) what buildings or structures should be built or torn down, and (c) how you would use the island to its best advantage. Draw a map of your proposed uses and changes.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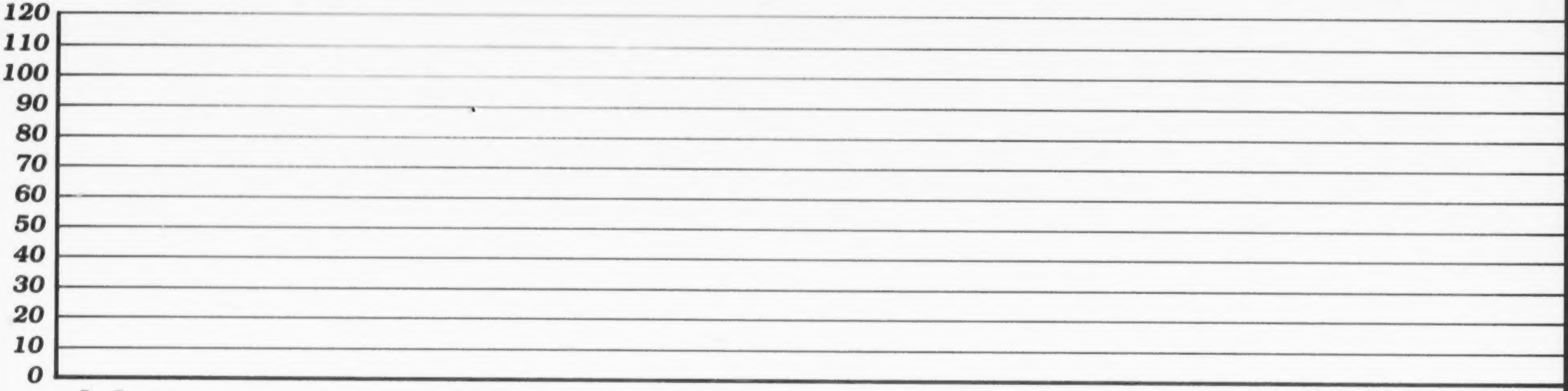
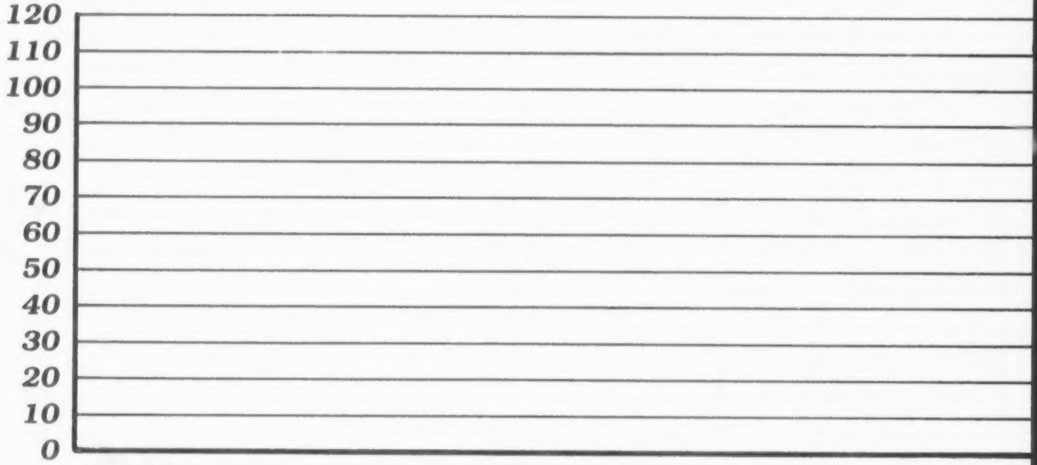
BELLE'S PROFILE



AA$_1$



BB$_1$

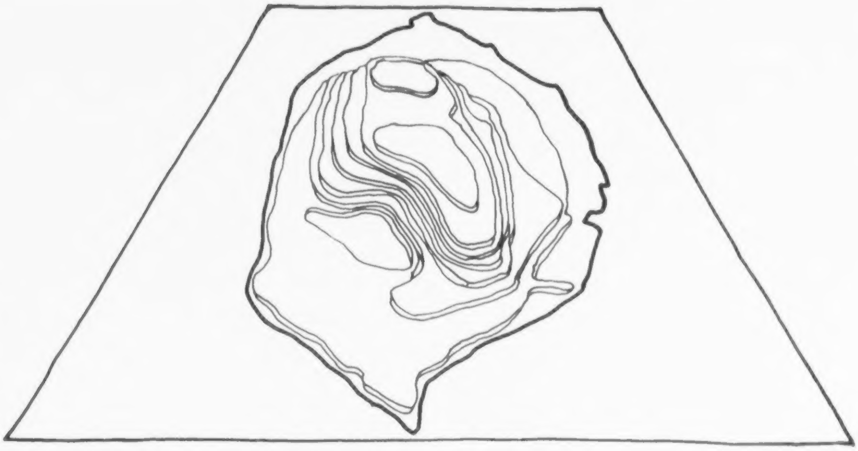
BELLE'S PROFILE SHEET

Science and Social Studies

SOL:
Science 9.2, 9.10
Social Studies 7.4, 9.1, 9.2, 9.3, 9.8

IIIc, IIIe, IIIf, IIIg

Skills: interpreting maps, making inferences, interpreting models



MAKE AN ISLAND

Objectives The student will (1) use a topographic map to construct a three dimensional scale model of Belle Isle, and (2) make inferences about the topographic features of the island.

Method Students will use a topographic map to construct a three dimensional scale model of Belle Isle.

Background Belle Isle is an island of approximately 65 acres in the middle of the James River located near the geographic center of Richmond. It is predominately a granite outcrop with a variety of topographic conditions.

In the early 1900's the western end of Belle Isle was the site of a quarry which is now filled with water. The elevation rises sharply on the east end of the quarry where the rocks were removed from the hillside. The flat open area on the east end of the island was used as a race track around 1827. People sat on the hillside facing east to watch the races. This section was also the site of a prison camp during the Civil War. The level area on top of the hill in the center of the island was farmed extensively in the 18th century. It was flat enough to allow cultivation and high enough to protect it from even the highest floods. That area is no longer used, however, and trees have reclaimed it. (See the HISTORY OF BELLE ISLE in this guide for more information).

Topographic maps in general identify both natural and man-made features. Some of the natural features usually shown are mountains, hills, lakes, rivers and plains. Man-made features depicted include schools, churches and other buildings, quarries, bridges and dams. A unique feature of a topographic map is that it shows *contour lines* which are marked according to elevation above sea level. The *contour interval* is the difference in elevation between two adjacent contour lines.

Materials Topographic map of Belle Isle, James River Park map, carbon paper *or* photocopies of the topographic map, 5-10 pieces of cardboard the same size as the topo map, scissors or utility knife, glue

Procedure Place the carbon paper under the topographic map and on top of a piece of cardboard.

Trace the outline of Belle Isle so that it is transferred onto the cardboard.

Cut the cardboard on the traced lines.

Repeat this procedure for each of the contour intervals. If you are using rather thick cardboard, you may only want to represent every 20 or 30 feet in elevation instead of every 10 feet as indicated on the topographic map.

Glue all of the pieces together from the lowest elevation to the highest and in their approximate location as shown on the topo map.

An alternative method of constructing your model is to use photocopies of the topo map instead of carbon paper. Count the number of contour lines on your map. Make that number of map copies plus one. Glue one map on a piece of cardboard and cut along the outermost contour line. Repeat with successive contour lines until you have all lines cut out.

(Activity directions adapted from *Science Scope: a Magazine for Middle/Junior High Science Teachers*, National Science Teachers Association, Vol. 10 no. 2, November 1986)

Have the students answer the following questions:

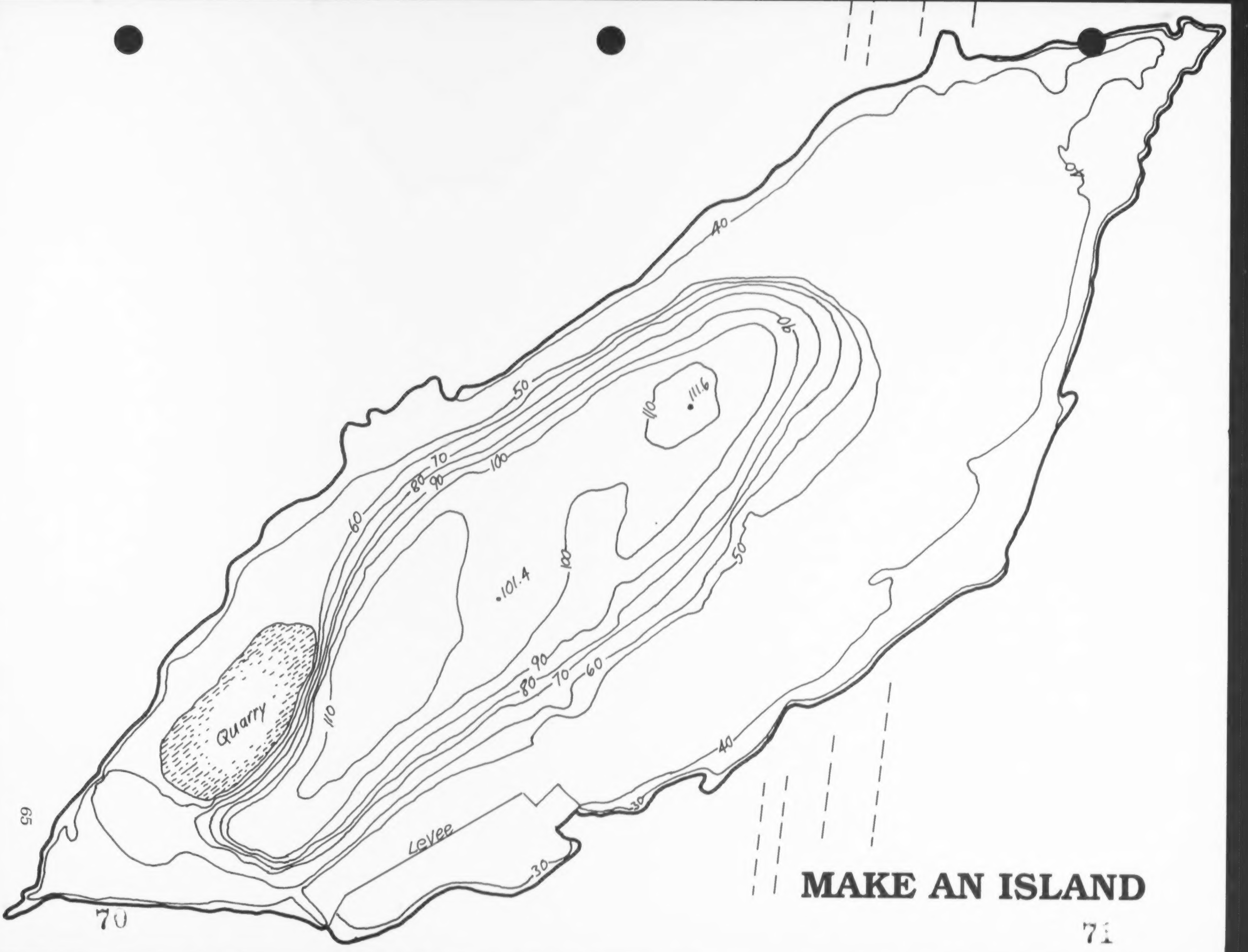
There was a horse race track on the island at one time. Where do you think it could have been located? Where might people have sat to watch the races?

There was once a Civil War prison camp on the eastern end of Belle Isle and, unlike today, there were few trees on the island at that time. Where do you think the guns were placed to guard the prison from a possible attack by Union forces from the south side of the river? Why do you think so?

Look at the topographic map to see where the steepest slope on the island is located. What kind of a physical feature does this represent? Do you think it is natural or man-made? Why do you think so?

During the 18th century some land on the island was farmed. Where do you think this farming took place? Why do you think so?

Use the map of the James River Park to check your inferences and see how accurate they were.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MAKE AN ISLAND

Science and Social Studies

SOL:
Science 9.2, 9.4, 9.9, 9.10
Social Studies 9.1, 9.2, 9.3, 9.8

Ia, Ic, IIIc, IIIg

Skills: interpreting maps, measuring, making inferences, interpreting models

JAMES' PROFILE

Objectives The student will (1) construct a graph showing the profile of the James River from source to mouth, and (2) use the profile to make inferences about the geologic regions and features which the river traverses.

Method Students will use a data table to construct a profile of the James River from its source to its mouth.

Background The James River begins near Iron Gate in Botetourt County at the confluence of the Jackson and the Cowpasture Rivers. It cuts through the Blue Ridge Mountains, and flows eastward through the Piedmont geologic province, a rolling landscape drained by numerous streams. Next it flows across the fall zone onto the coastal plain and finally empties into the mouth of the Chesapeake Bay.

Approximately 40 miles from its source and just below the Balcony Falls Dam, the river passes through a narrow gorge, creating spectacular white-water enjoyed by recreational canoeists, kayakers, and rafters.

At about river mile 75, the city of Lynchburg lies on the western end of the Piedmont. In passing through the Piedmont, the river falls at the slow rate of one to two feet per mile, cutting its way into bedrock, occasionally depositing *alluvium* (sediment), which is washed away by periodic floods. Small flood plains with fertile alluvial soils have been created along the river banks in this region.

On the eastern end of the Piedmont, 220 miles from its source, the river reaches Richmond and the *fall zone* (sometimes called the fall line). It drops 105 feet in approximately 7 miles, reaching sea level at the 14th Street Bridge. The area of the fall zone in Richmond, particularly the rapids near Hollywood Cemetery and just north of Belle Isle, is another area of the river which provides excellent white-water boating.

From the eastern end of the fall zone the river becomes tidal, rolling slowly over the coastal plain. The Atlantic Coastal Plain is made up of a wedge of sediments deposited by the river when it floods and by the ocean during its periodic invasions over millions of years.

Materials James River Profile worksheet

Procedure Use the data identifying miles from the source and feet above sea level on the Profile worksheet to plot points on the graph provided.

Connect the points with a smooth, curved line to illustrate the profile of the river.

Identify the areas on the profile which represent (a) the Valley and Ridge, (b) the Piedmont, (c) the Fall Zone, and (d) the Coastal Plain.

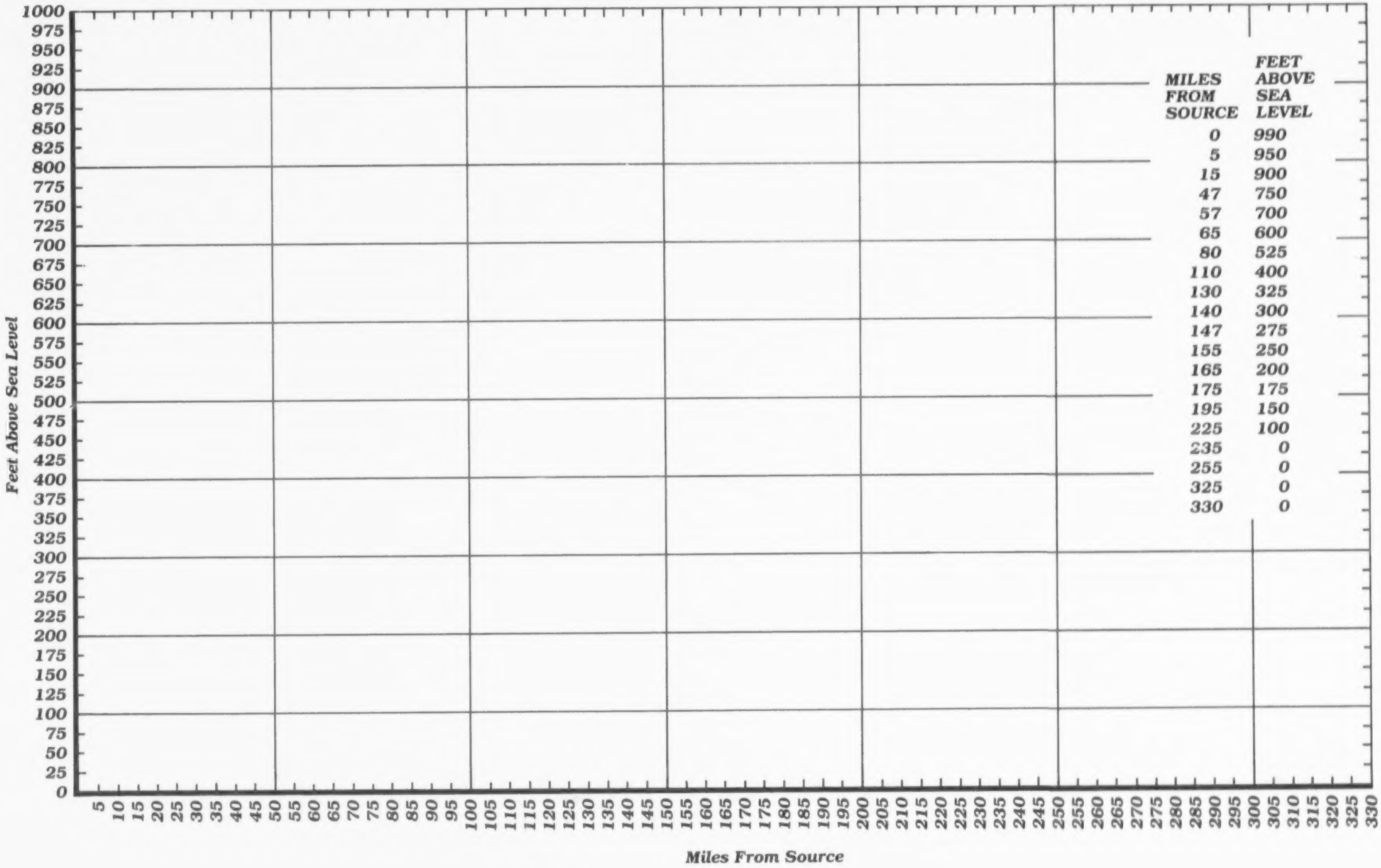
The James River contains several areas of white-water rapids ideal for recreational boating in canoes, kayaks, and rafts. Where do you think these rapids are located? Why do you think they are there?

Virginia Power Company has operated hydroelectric generating plants in several locations in Richmond. Why do you think they were built in Richmond rather than in Hopewell or Newport News?

Where do you think the river becomes tidal? Why?

Where is there the greatest potential for erosion by the river? Why?

Where do you think the most sedimentation occurs? Why?



MILES FROM SOURCE	***FEET ABOVE SEA LEVEL***
0	*990*
5	*950*
15	*900*
47	*750*
57	*700*
65	*600*
80	*525*
110	*400*
130	*325*
140	*300*
147	*275*
155	*250*
165	*200*
175	*175*
195	*150*
225	*100*
235	*0*
255	*0*
325	*0*
330	*0*

JAMES RIVER PROFILE

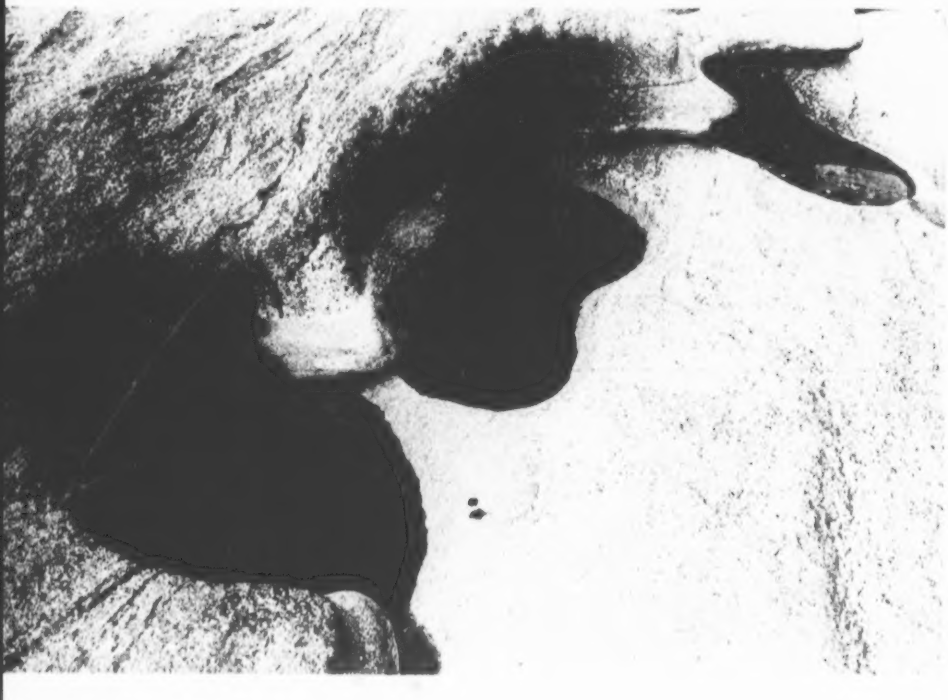
Science

SOL: 5.12, 5.16, 7.1, 7.4, 7.5, 7.15, 7.16, 9.2, 9.6, 9.9

Ia, Ic

Skills: observing, measuring, making inferences, gathering data, graphing

POTHOLE PEEKING



Objectives The student will (1) describe how potholes are formed in rocks, (2) compare shapes and locations of potholes, and (3) describe the conditions to which organisms living in potholes must adapt.

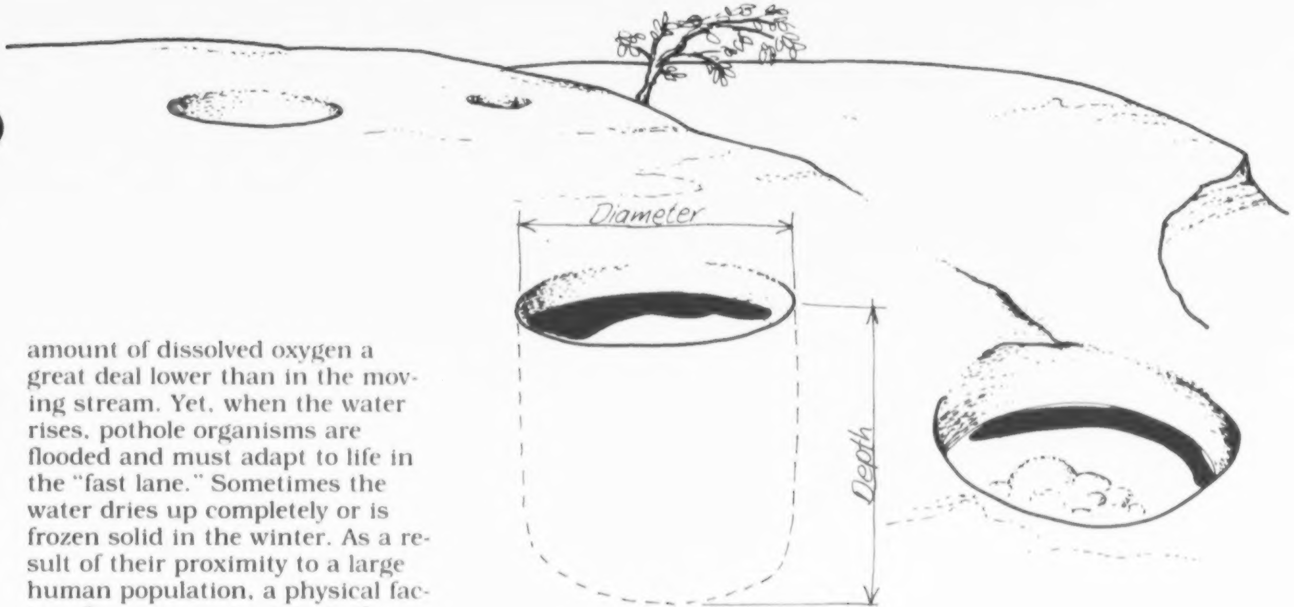
Method Students will observe, measure, and make inferences about the potholes in the rocks of the James River fall zone.

Background The rocks in the fall zone of the James are huge chunks of granite with denser and darker inclusions or xenoliths ("xeno" meaning foreign, and "lith" meaning rock). The granite in this area and on Belle Isle is known as Petersburg granite and is thought to be about 330 million years old.

The numerous potholes are one of the most striking features observed by anyone visiting the river in Richmond. They form when small rocks washing down from upstream get trapped in a crack or depression and are whirled around and around by the water, gradually eroding a circular or oblong hole in the large rock over a period of thousands or millions of years. Potholes seem to occur primarily along joints, beginning as small holes which continually grow larger every time high water covers the rock and small whirlpools develop in the swiftly moving currents. The holes may be elongated in the direction of the joint.

In colonial times people thought that the Indians had scooped out the holes to grind corn. They didn't believe something as perfectly proportioned as these features are could be formed naturally.

Life in the potholes must be adapted to a wide variety of physical conditions. Water temperature in these self-contained pools can be significantly higher and the



amount of dissolved oxygen a great deal lower than in the moving stream. Yet, when the water rises, pothole organisms are flooded and must adapt to life in the "fast lane." Sometimes the water dries up completely or is frozen solid in the winter. As a result of their proximity to a large human population, a physical factor of more recent origin is the concentration of pollutants in the James River fall zone potholes. Only a few plants and animals are adapted to survival under such harsh conditions.

Materials Scoop (or any instrument for picking up the small stones found inside potholes), meter stick, hand lens, graph paper, thermometer, dissolved oxygen test kit (optional), white enamel pan or clear plastic container

Procedure Go to the fall zone of the James River during a period of low water, so that you can walk out on the rocks. Call 804-226-4423 shortly before the trip to get a report on the water level as measured at the Westham gauge. The water level is considered low if it is 3.0 feet or less, but the rocks in the area of the James River Park are accessible even up to 5.0 feet.

If the level is 6.0 feet or above, it is dangerously high for any activity on the river and your trip should be postponed. Life jackets are recommended if you are taking students to the James River. They can be borrowed from the James River Park naturalist. Call 231-7411 for more information.

The best approach to the fall zone is from the James River Park on the south side of the river, the east end parking lot of the Park (near 22nd Street). The rocks between the railroad track and Belle Isle contain numerous potholes which can be easily reached by foot when the water is low.

Have the students do one or more of the following activities:

Measure and record the *depth* and *diameter* of several potholes of different sizes. Carefully observe the shape of each pothole. If it does not appear to be perfectly round, measure the smallest and the largest diameters and average them. Many potholes do not have a level top opening. Again measure the smallest and largest depth and use the average. (Do *not* measure the water depth. It changes frequently and is not related to the size of the hole.)

Using graph paper, plot the average diameter and depth of each hole to see if the two dimensions are related.

Use a scoop to take out some of the rocks contained inside a pothole. (NEVER use your bare hands because there may be glass or other sharp objects inside.) Carefully observe the rocks and classify them as to size, shape, type of rock, etc. Be sure to return all rocks to their original pothole . . . they still have work to do!

Describe the appearance of the water and objects other than rocks found in various potholes.

Measure and record the temperature (and the dissolved oxygen content if you have the equipment) of the water in several potholes and compare it to that of the running water.

In your container collect and observe the living organisms you find inside several potholes. Then collect some from a section of moving water. Make a list of your findings. Return the organisms to their original habitat. (See the activities called CRITTER COLLECTING and CRAZY CRITTERS for more suggestions about observing living organisms.)

Have the students answer the following questions:

How do you think the potholes were formed?

Are all potholes perfectly round? Why do you think they are or are not?

What is the relationship between the diameter and the depth of the potholes?

What did you observe about the rocks inside the potholes? Where do you think they came from? Why do you think so?

Are the organisms the same in all of the potholes? Why do you think this is true? How do they compare with the kinds of organisms in the moving water?

To what kind of conditions do pothole organisms have to be able to adapt in order to survive?

Science and Social Studies

SOL:
Science 4.5, 4.12, 4.15, 6.2, 6.20, 6.21, 9.9
Social Studies 6.3, 8.8, 9.6, 9.8

Ia, Ic, IIb, IIc, IId, IIe

Skills: observing, measuring, making inferences, experimenting (controlling variables)

SAVE THAT SOIL

Objective The student will explain that vegetation and horizontal grooves (contour plowing) on a slope help reduce the amount of soil erosion that takes place during a rain.

Method Students will simulate rainfall on a slope (either in the classroom or on the schoolgrounds) and observe the effect that vegetation and horizontal grooves have on soil erosion.

Background Whenever rain falls on the land, soil particles are carried by the water into streams and eventually into rivers. If vegetation has been removed (such as when a field is plowed before planting or land is cleared to build highways or buildings), much greater amounts of soil erode and are carried into the waterways. Look at a river or stream after a heavy rainfall and you will see that it often looks brown or muddy from all of the sediment that has been washed into it.

Excessive amounts of sediment reduce the amount of sunlight that can penetrate into the water and therefore limit the depth at which plants can grow. Sediment in the water eventually settles to the bottom and can suffocate bottom dwelling organisms such as oysters and clams. Suspended particles also *adsorb* metals, nutrients, oils, chemicals and other potentially toxic compounds which remain in the bottom sediments for long periods of time. Finally, when soil is eroded from the land, it fills in river channels and harbors creating a problem for navigation.

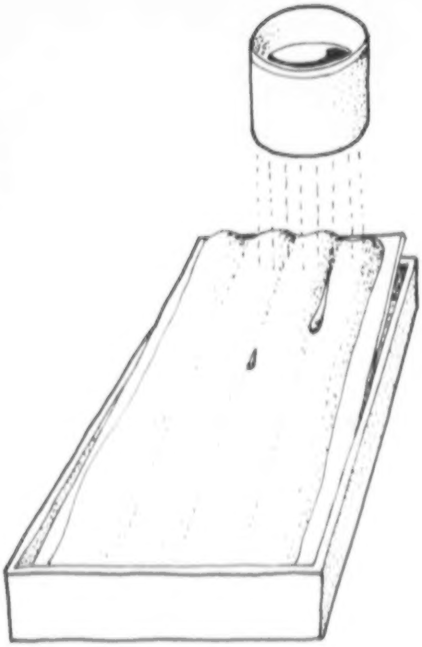
One of the major problems causing a decline in the submerged aquatic vegetation and the oyster harvests in the Chesapeake Bay in recent years is the amount of sediment being carried into the Bay by the rivers along its western shore. The James River is a significant contributor to this problem.

After the "Dust Bowl" of the 1930's, many farmers adopted soil conservation practices to slow down the loss of their top soil. Some of the techniques used to conserve soil were contour plowing (plowing around a hill rather than up and down the slope), and the use of "cover crops" to avoid having the soil remain bare and vulnerable to erosion for long periods of time during the winter. Low-till or no-till are methods of farming which eliminate the need for ever having the soil lie bare. However, these practices necessitate greater use of herbicides (to kill weeds) and insecticides (to kill insects) in order to get high yields from the crops. Some new technologies have increased the efficiency and speed of plowing, cultivation, and harvesting, but have caused farmers to abandon many of the basic conservation techniques.

Construction sites are another major source of sediment in rivers. Highway construction companies and developers are supposed to put up wind breaks and hay bales, and plant grass or ground covers as soon as possible after clearing land for construction. These practices are able to *reduce* the amount of soil erosion in such areas, but they do not eliminate it totally.

The United States Department of Agriculture, Soil Conservation Service has several district conservation offices in the Richmond metropolitan area. The people in these offices can give you more information about specific soil conservation laws and practices. Their addresses and phone numbers follow:

Chesterfield County
6319 Courthouse Road, Prince George, VA 23875, 732-1866.



Goochland and Henrico
Counties and Richmond City
P.O. Box 66, Goochland, VA
23921, 556-4125.

Hanover County
Commonwealth Professional
Bldg., 305-B South Washington
Hwy., Ashland, VA 23005,
798-8107.

For additional information about soil erosion, see p. 10 in the "Getting Acquainted with Nature: Our Fresh Water Resources" booklet contained in this guide.

Another good resource for information and activities about soil is a booklet called *Conserving Soil: A Practical Teaching Guide.* It contains a 16-page teacher's guide of background information, four full-color overhead transparencies, and 24 ditto masters. Activities include: digging in soils to see what (and who) is there, how native Americans used the land and its soils, figuring out how soils are formed, seeing how soils shaped American history, learning how to match land uses to soils in a good way, and discovering current issues in soil conservation. It was designed for science and social studies teachers in grades 6-9 and can be ordered for $8.50 from the offices listed above or from NACD Service Department, P.O. Box 855, League City, TX 77573.

Materials

ACTIVITY A—bucket of water, sprinkling can or tin can with holes punched in bottom, shallow pan or box, board to fit inside pan or box, moist soil to put on top of the board, 2 glass or clear plastic containers

ACTIVITY B—two buckets of water, meter or yardstick, two areas on school ground with approximately the same slope—one with grass or vegetation and the other with bare soil, 2 glass or clear plastic containers

Procedure

ACTIVITY A—Use the pan, board and moist soil to build a simulated slope as shown in the illustration.

Use a pencil to scratch grooves in the soil running up and down the slope. Use the sprinkling can to create "rain" on your slope (about half a quart of water is sufficient). After all of the water has run down the slope into the pan, pour it into one of the glass jars.

Clean out the pan and start over, but this time scratch grooves in the soil horizontally to simulate contour plowing of a field on a slope. Repeat the "rain" procedure and pour the collected water in the other jar. Label the jars to identify which sample they hold.

Compare the amount of soil in each of the jars. In order to make better observations and inferences, you may need to let the jars stand for several hours so that the sediment settles to the bottom. You could also pour the water from each jar through a filter (such as a coffee filter) to see how much soil was washed away in each of the situations.

Discuss the results and ask the students to recommend the best method of plowing to reduce soil erosion.

Activity B—Find an area on the school grounds that is barren of grass and other vegetation and which has a slight slope to it. Any area which is approximately 8-10 square feet or larger will suffice. Next locate another area with about the same slope, which has grass or other plants covering it.

Pour a bucket of water at the top of the bare soil slope. Observe what happens as the water runs down the slope. Ask the students to draw or describe what they observe. If possible, collect some of the water that has run down the slope. Measure the distance the water flows before it finally stops.

Next pour the same amount of water at the top of the slope with vegetation on it. Measure the distance the water flows and try to collect some of the water after it has run down the slope.

Ask the students the following questions:

Which slope does the water run down faster?

Compare the water you collected at the bottom of each slope. What differences do you observe?

What happens to the soil on a bare slope every time it rains?

After a lot of rain rivers often look dirty. Why do you think that happens?

When rivers have a lot of sediment in them, what problems do you think might be created for plants and animals living in the water?

Soil that is washed into rivers eventually settles to the bottom. What kinds of problems do you think this sediment accumulation could create for ships that travel on the rivers?

From where do you think sediment or soil in rivers comes?

What measures could be taken to reduce the amount of soil erosion?

Extension After a heavy rain, collect water from a stream or river near a plowed field or a construction site and put it in a clear glass or plastic container. At the same time, collect water from a stream or river that runs through a forested or vegetation-covered area and put it in a jar which is the same size as the first. Let the water in the two containers stand for a few days so that the sediment will settle to the bottom. Compare the amount of sediment in the two jars and make inferences as to why you think there are differences.

Science

SOL: 6.2, 6.3, 6.13, 6.14, 6.20, 7.1, 7.2, 7.5, 7.16, 7.17, 7.18

IIb, IIc, IIId, IVa

Skills: observing, measuring, making inferences, gathering data, experimenting (controlling variables)

TEMPERATURE AND DISSOLVED OXYGEN

Objectives The student will (1) describe the effect of water temperature on the amount of dissolved oxygen in a body of water, (2) tell how the amount of dissolved oxygen affects aquatic life, and (3) identify the time of year and general locations where reduced oxygen levels are a problem in rivers.

Method Students will conduct an experiment which illustrates the effect of temperature on the amount of dissolved oxygen in water.

Background Most living organisms need oxygen in order to survive. Even those which live in water depend upon oxygen dissolved in the water for respiration. Water in various locations does not always contain the same or adequate amounts of dissolved oxygen to support fish or other living organisms. In general, cold water can hold greater amounts of dissolved oxygen than can warm water. Another factor affecting oxygen content is the fact that warm water allows plankton (microscopic organisms) to reproduce rapidly. The zooplankton (microscopic animals) consume oxygen as they breathe, thereby further depleting the oxygen supply in warm water. The phytoplankton (microscopic plants) produce oxygen during photosynthesis, but *consume* oxygen when the sun is not shining.

This activity illustrates the effect that temperature has on the amount of dissolved oxygen in water. Yeast is used to represent plankton or bacteria normally found in river water. Yeast cells need the milk in this activity in order to multiply, just as plankton and bacteria need food or nutrients. Methylene blue, which can be ordered from a science supply catalog, is used to tell whether there is oxygen present in the water. When a test tube remains blue, it means there is still oxygen present. When the blue begins to fade, there is less oxygen.

The test tube in the warm water (letter B) should be depleted of oxygen within 10-15 minutes (the blue should fade to nearly white). Test tube A will gradually change to a lighter shade of blue, but the process will take much longer than it did for B.

This activity simulates the conditions in a river either in the warm summer months or near a power generating plant or other industrial site which returns warmed water to the environment.

The measurements do not need to be exact in order to get proper results in this experiment. The variables which are controlled (held constant) are the amount of food and yeast. The manipulated variable is the temperature. The responding variable is the amount of oxygen, indicated by the shade of blue.

The graphs in this activity are from a report prepared by the Virginia Institute of Marine Science. VIMS sampled the water in the James River from Richmond to Hampton Roads (the slack water) from 1971-1985 and conducted several water quality tests on the samples. Graph A shows the variation in low dissolved oxygen concentrations throughout the year for the lower portion of the James. Graph B shows the variation in mean (average) temperature for a year. In comparing the graphs you can see that the low dissolved oxygen levels peak at the same time as the water temperatures are the highest. These peaks occur in late summer when the photosynthetic activity is high and water flow is low.

See pp. 28 and 42 in the "Getting Acquainted with Nature: Our Fresh Water Resources" booklet contained in this guide for more information about the relationship between temperature and oxygen in water.

Materials powdered milk, yeast, water, methylene blue (order from a science supply catalog), metric measuring spoons, graduated cylinder, 2 test tubes, test tube holder (or cup to hold a test tube), beaker (glass or plastic cup) thermometer (optional), eye dropper, 2 cups or small containers

Procedure Label the test tubes: A and B.

Make a milk (food) solution in one of the cups or containers by adding 3 ml of powdered milk to 60 ml of water.

In the other container, add 3 ml of yeast (represents living organisms, bacteria) to 60 ml of water.

Fill a beaker, half full with hot tap water (approximately 40 degrees Celsius).

Add 3 ml of milk solution to test tubes A and B.

Add 3 drops of methylene blue (oxygen indicator) to EACH of the test tubes and stir.

Add 2 ml of yeast solution to EACH test tube. Stir or shake the contents of the test tubes to mix the ingredients completely.

Quickly put test tube B into the beaker of hot water and place test tube A in the test tube holder. Record the time.

Observe each test tube carefully. Watch for a complete color change in each. If it occurs, record the approximate length of time it took for each test tube to change color. Make a chart to compare the results easily.

Have the students answer the following questions: What are the controlled variables in this experiment? What is the manipulated variable?

In which test tube did the color change occur faster? Why?

What was using up the oxygen in the water?

If a fish required a lot of oxygen, would it prefer to live in warm or cold water?

Look at the graphs showing the results of dissolved oxygen and temperature tests on the James River between Richmond and Hampton Roads. During what time of year are the *greatest number* of *low* dissolved oxygen readings taken?

Compare the dissolved oxygen graph with the temperature graph for the James. What comparisons can you make between temperature and the dissolved oxygen content of the river?

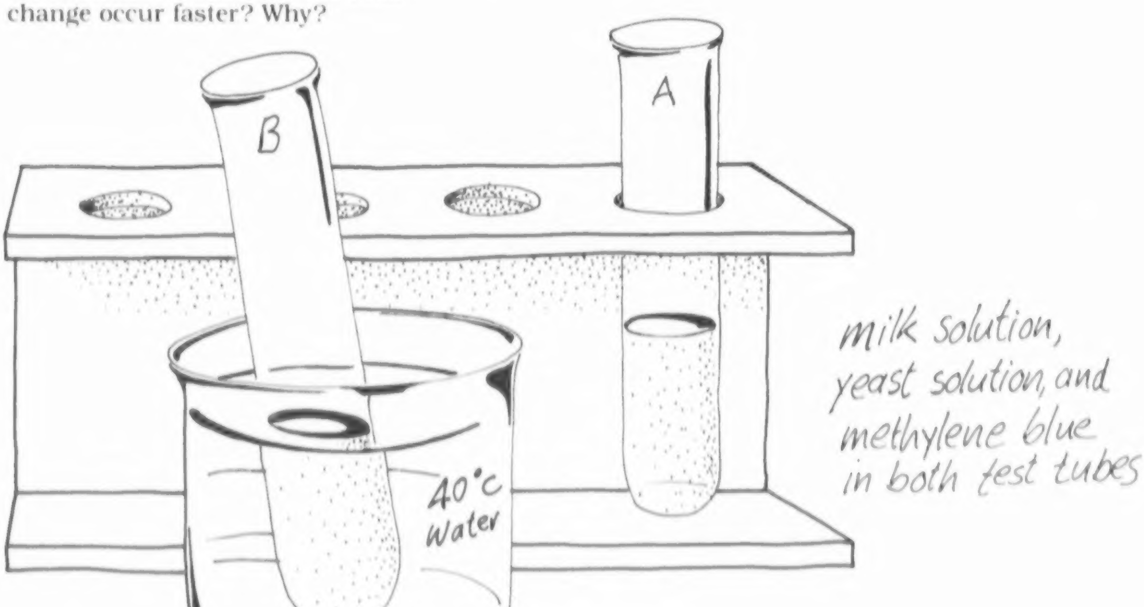
Describe the conditions you would expect to find in late summer and explain how they would affect the amount of dissolved oxygen in the water.

How might a power generating plant or other industry affect organisms in the river below the plant?

Extension To show the students what would happen if there were no living organisms in the water to consume oxygen, set up the experiment again. This time do everything the same as before *but do not add any yeast to either test tube*. This time the test tube in the warm water should remain blue indicating that oxygen is still present.

This activity was adapted from one found in the *Chesapeake Bay Education Week Guide*, December 1983. Council on the Environment, Richmond, Virginia.

Graphs were adapted from "Preliminary Analysis of James River Slack Water Data 1971-1985 With Emphasis on Dissolved Oxygen Data", *Virginia Water Quality Assessment 1986 Volume Two of Two Information Bulletin 565, April 1986, Virginia Water Control Board.*



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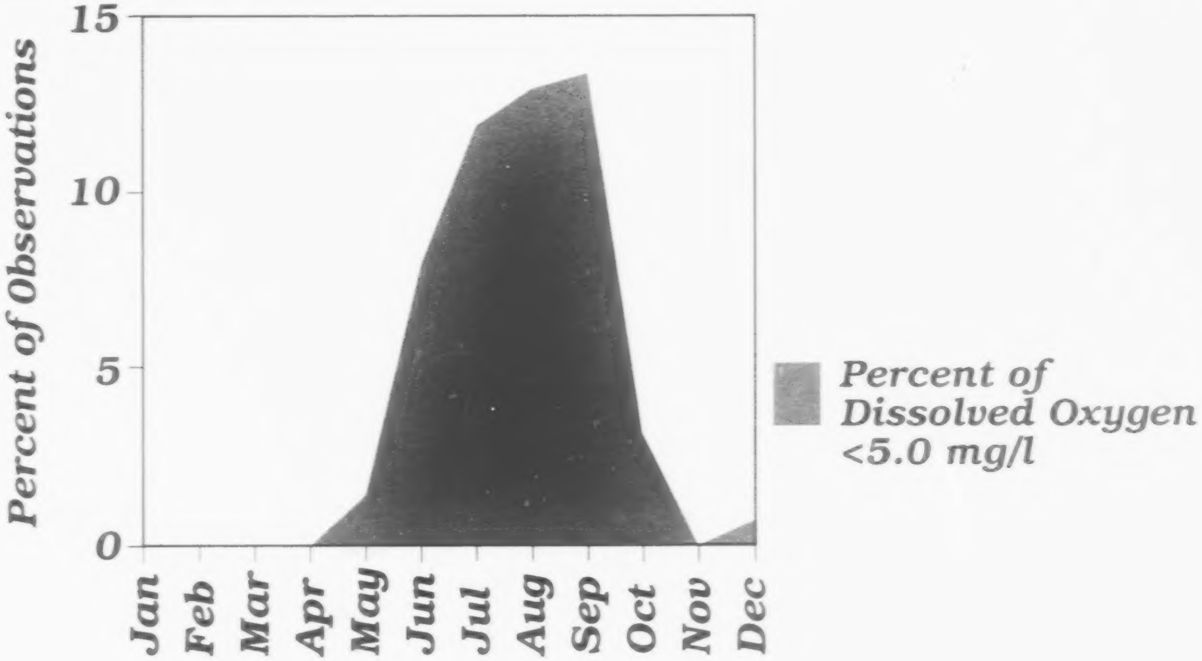
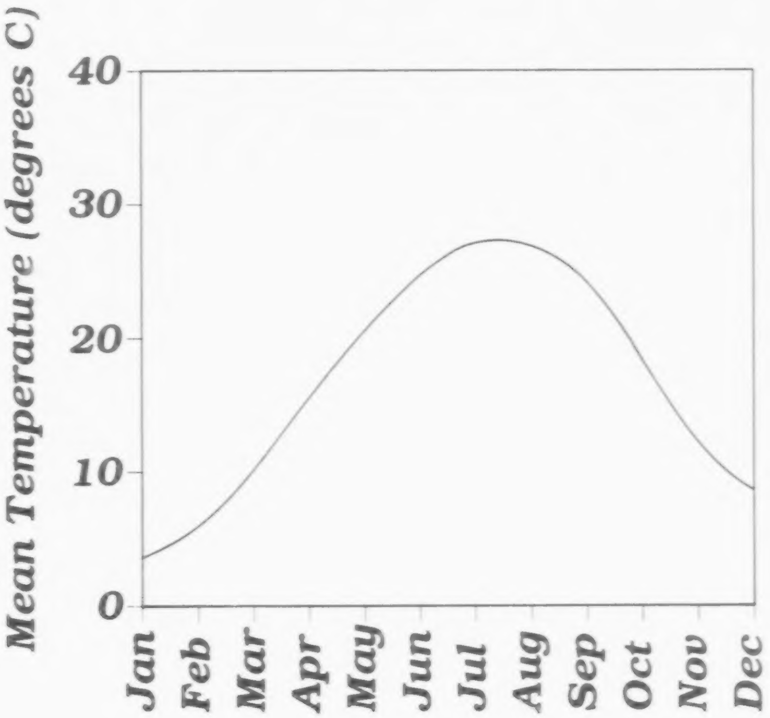
GRAPH A



GRAPH B



Science and Social Studies

SOL:
Science 4.3, 4.4, 4.5, 4.14, 4.15, 5.2, 5.3, 5.11, 6.2 6.14, 6.20, 6.21, 7.1, 7.5, 7.14, 7.16, 7.17, 7.18, 7.19
Social Studies 8.3, 8.8, 9.8

Ib, Ic, IIb, IIc, IIe

Skills: observing, measuring, making inferences, questioning, gathering data, experimenting (controlling variables)

NUTRIENTS AND WATER QUALITY

Objectives The students will (1) give a general description of the term "eutrophication," (2) describe the changes in algae populations which occur when fertilizer is added to ponds or rivers, and (3) explain the problems associated with algal blooms in bodies of water.

Method Students will conduct a controlled experiment to test the effect of the nutrients nitrogen and phosphorous on the growth of algae in water.

Background Two of the primary ingredients in plant fertilizer are compounds of nitrogen and of phosphorous, elements necessary for plant growth. When large amounts of these nutrients are present in water, however, excessive growth of algae occurs. This often sudden growth is called *algal bloom*, and can be recognized as green slime or as dense mats of brownish-green material floating in water.

Algae, like all green plants, produce oxygen through photosynthesis. In the absence of light, however, green plants absorb oxygen, temporarily reducing the amount available in the immediate environment. In a river or pond, this results in less oxygen being available for other organisms, such as fish. Also, as large quantities of algae die in a relatively small volume of water, a great deal of oxygen is consumed by decomposer organisms. This sequence of events is called *eutrophication* (from a Greek word meaning "well-nourished"). Eutrophication occurs naturally over a long period of time. Eventually, any standing or slow-moving body of water is filled in with sediments and plants, and becomes dry land. In many areas, man's activities have accelerated the process dramatically, and bodies of water are "dying" prematurely.

Below is a summary of some of the major changes occurring during eutrophication:

Biological Changes, large aquatic plants increase growth, algal blooms occur, aquatic animals die as a result of increased bacterial action

Physical Changes, layers of dead organisms, especially algae, accumulate on the bottom, decreasing the depth of the body of water, water becomes distasteful and malodorous, color changes occur in water

Chemical Changes, level of toxins increases, dissolved oxygen (DO) decreases, stress occurs when DO is between 4 mg/l and 9 mg/l, death occurs when DO is below 2 mg/l

Agricultural runoff is a major source of excess nitrogen and phosphorous in rivers. When rain falls on fertilized fields and lawns, dissolved nutrients are carried by runoff into streams and rivers. It has been estimated that 27% of the phosphorous and 60% of the nitrogen in the Chesapeake Bay comes from cropland in the Bay drainage basin. This is one type of *non-point pollution*, or pollution that comes from a wide area rather than from a single place.

Until recently, another major source of phosphorous pollution was high-phosphorous detergents. Many dishwashing and laundry products contain phosphates as cleaning agents. Unfortunately, neither primary nor secondary sewage treatment removes these compounds from wastewater, so the discharge from treatment plants may contain high levels of phosphorous. This is *point source pollution*, as it enters the river at an identifiable point. [Find out more about sewage treatment in the activity called DOWN THE DRAIN.] Some detergent products are low in phosphates or phosphate-free. The 1987 Virginia General Assembly passed a law banning the sale of any laundry detergents containing more than 0.5% phosphorous. The law also limits dishwashing detergents to 8.7% phosphorous. This level of phosphorous is the minimum which will prevent water spots on dishes. Even though the dishes would be clean, consumers have been conditioned by advertising to dislike spots on eating utensils!

See pp. 24-34 of the "Getting Acquainted with Nature: Our Fresh Water Resources" booklet contained in this guide for more information about the sources and results of excess nitrogen and phosphorous in water.

In this activity the jars with fertilizer and detergent added to them should exhibit the fastest changes in appearance and odor illustrating what happens in a pond, lake, or river when too many nutrients are present as a result of man's activities.

Materials 4 quart jars, plant fertilizer (preferably one which will not color the water to which it is added), dishwasher detergent containing phosphorus (look at the label to see what percentage of phosphorus or phosphates it contains), algae water (collect from a pond, a stagnant portion of a river, an aquarium just before it is cleaned, or make your own by letting tap water stand for several days—to allow any chlorine to evaporate—and then add a mat of straw, hay, or grass clippings to it, allowing *that* to stand for several days)

Procedure Discuss the terms *algal bloom* and *eutrophication* with your students. Describe the natural processes that take place in a body of water and tell how man's activities have hastened the aging process in rivers and lakes. Ask the students to design an activity to see what factors influence algal growth in water (or use the one described here).

Label the jars A, B, C, and D. Fill each with the same amount of algae water and set them in a warm sunny place. Jar A will be the control and therefore will have nothing more done to it. Put 3 teaspoons of fertilizer in jar B, 3 teaspoons of detergent in jar C, and 3 teaspoons each of fertilizer and detergent in jar D. Put a piece of paper over the mouth of each jar to reduce evaporation.

Have students record the appearance of all four jars either in writing or by drawing or taking a photograph at the beginning of the experiment. Put all of the jars in a warm, sunny location. Observe the jars every two days for a period of several weeks, recording their appearance and odor each time.

After an obvious change has taken place, discuss how this situation is similar to what happens in rivers and the Chesapeake Bay and have the students answer the following questions:

Which jar changes the most? How can you explain this?

Are there changes other than just the appearance of the jars (how about smell)?

What was the purpose of jar A?

How does this experiment compare to what happens in the James River and the Chesapeake Bay?

Where do you think the nutrients (fertilizer and detergent) in the Bay and rivers come from?

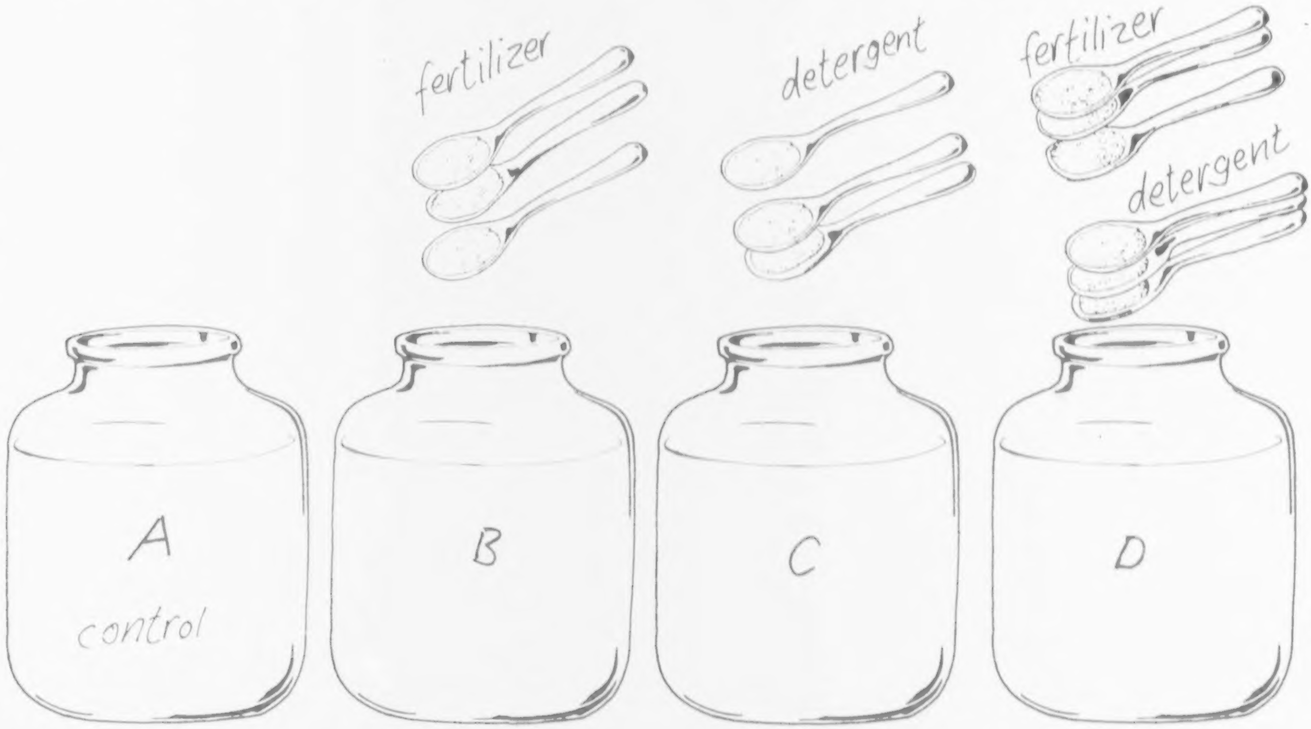
What could you and your family do to help reduce the nutrients in the river and the Bay?

What is the difference between point and non-point pollution?

Which of the two types of pollution is more difficult to control and regulate? Why?

Investigate the deliberations of the 1987 Virginia General Assembly in deciding to regulate the phosphorus content of detergents. Which groups were in favor of the regulation and which were opposed to it and why? (For more information call either the *Council on the Environment*, 903 Ninth Street Office Building, Richmond, Virginia, 23219, 804-786-4500 or the *Chesapeake Bay Foundation*, 1001 East Main Street, Suite 815, Richmond, Virginia 23219, 804-780-1392)

Extension This experiment could be varied by having different groups of students use greater amounts of fertilizer and detergent to see if quantity affects the outcome. Another possibility is to use different sources of water—tap water that has not been aged, and water from different ponds, a stagnant pool, and various sections of the river such as just above a sewage treatment plant outflow pipe and just below it.



POISON IN THE FOOD CHAIN

Science and Social Studies

SOL:
Science 4.14, 4.15, 6.16, 6.20, 7.13, 7.15, 7.18
Social Studies 6.3, 8.8, 9.6, 9.8

Ib, IIb, IIc, IIIc, IIId, IVa

Skills: making inferences

Objectives The student will describe (1) the way in which poisons are concentrated in a food chain, and (2) some consequences of poisons in food chains.

Methods Students will take the part of mayflies, striped bass, and ospreys and play a game of tag illustrating the interaction of these organisms in a food chain.

Background *Pesticide* is a general term which refers to chemicals or other substances used by people to control unwanted organisms. *Herbicides* kill unwanted plants, and *insecticides* kill insects. We depend a great deal upon pesticides today for everything from keeping termites away from our homes to improving the yield from farm crops so that we will have enough food to eat.

Unfortunately pesticides can create problems in addition to helping people. Many of them are *persistent*, which means that they don't easily break down into harmless substances and therefore they "hang around" in the environment for a long time. Persistent pesticides often end up in places far away from where they were originally used because they get washed into streams and rivers or seep into the groundwater. They often move into the food chain, affecting many more organisms than the original target "pest."

DDT was such a pesticide. It was used extensively for many years to control insects on cropland. However, insects which ate the DDT and died (or did not die —there are always a few which are not killed by a particular pesticide) were eaten by other animals, which were eaten by other animals, etc. Each time an animal ate another with DDT in its body, the predator accumulated more and more DDT in its system. Eventually animals at the top of the food chain, such as eagles and ospreys, had high concentrations of the poison in them. Sometimes they died directly, but often the effect was that adult birds laid eggs with very thin shells. When the parent tried to sit on the eggs to keep them warm they were crushed, so few offspring were being raised. Populations of bald eagles, ospreys, and brown pelicans in particular were greatly reduced as a result of DDT until its use was banned in the United States in the early 1970's. Since that time, the number of these birds has increased gradually. However, DDT is still used in other countries, so it continues to enter the worldwide food chain. It has been found in the fat of walruses in the arctic, penguins in the antarctic, and in the breast milk of nursing mothers in every nation on earth!

For more information about biological magnification of pesticides in the food chain, see pp. 20-23 in the "Getting Acquainted with Nature: Our Fresh Water Resources" booklet contained in this guide.

Kepone is a chemical relative of DDT, which was made infamous when large quantities of it entered the James River in the mid-70's. Kepone was an insecticide manufactured by Allied Chemical Company and a contractor called Life Sciences Products (LSP) at Hopewell, Virginia. LSP was in operation for less than two years and kepone was their only product. The people in charge of LSP were very careless in their handling of the chemical. Kepone dust clouded the air around the site, workers carried it home on their clothing, and it was washed into the Hopewell sewage treatment plant and then into the James River. In addition to killing the digester bacteria at the sewage treatment plant, it was found that the kepone was extremely toxic to the nervous system of the people exposed to it.

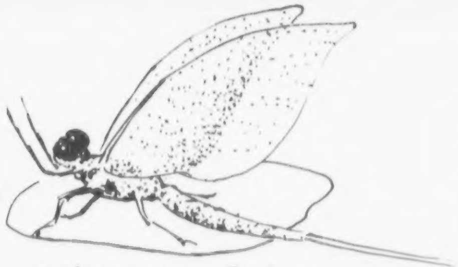
In July, 1975 the LSP plant was closed, but the damage had already been done. The Virginia Department of Health closed the James River to commercial fishing below Hopewell because of the kepone contamination. A federal district judge in Richmond fined Allied Chemical 13.2 million dollars for its part in the disaster, and directed that $8 million of that amount would be used to establish the Virginia Environmental Endowment. This private organization now supports environmental quality studies and educational activities (such as the development and dissemination of this activity guide) throughout Virginia.

Because pesticides sometimes have negative consequences such as those described above, which outweigh the benefits, some farmers are using alternative techniques to get rid of unwanted organisms. For example, they are using sprays of organic, non-toxic substances; crop rotation; or companion planting to control pests. Sometimes biological controls such as predatory insects can be used to eat the unwanted pests. Another method which works sometimes is the genetic approach—such as releasing sterile male insects of the "pest species" to compete with fertile males so that the females will not be able to reproduce. Your city or county VPI Agricultural Extension office should be of some help in finding out more about alternative methods of controlling weeds and insect pests.

Materials 20 white food chips *per student* (made of any sturdy material—1 inch squares cut from poster board work well), 10 colored food chips *per student*, 1 paper bag per student, colored arm bands or name tags to identify each of the three types of critters in this activity, whistle for the teacher to call "time"

Procedure Before beginning this activity, discuss food chains with the students to be sure they have a good understanding of the concept.

Divide the class into three groups —mayflies, striped bass, and ospreys. There should be approximately three times as many bass as ospreys, and three times as many mayflies as bass (so that a class of 26 would have 2 ospreys, 6 bass, and 18 mayflies). Use different colored arm bands or name tags of some sort to identify each



student as a mayfly, bass or osprey. If your numbers don't work out exactly right, add more mayflies and bass, but not more ospreys.

Mix the white and the colored food chips together and spread them around the area you are going to use. It can be a classroom with the chairs pulled to the sides, a gymnasium, or an outside playing field.

Give each mayfly a paper bag and explain that this is its "stomach" and the white and colored objects are its "food." While the bass and the ospreys sit quietly and wait . . . give the mayflies about 30 seconds to gather as many food chips as they can and put them in their stomachs.

After the mayflies have had this chance to get fat, let the bass begin to participate. If you are using a small area, allow 15 seconds for this next phase, or about 60 seconds if you are outside in a large area. When the teacher gives the signal, let the bass try to catch the mayflies for dinner. When a mayfly is tagged, it must give its bag of food to the bass who tagged it and go sit on the sidelines and watch for the rest of the round. Encourage the bass to catch as many mayflies as possible in the time allowed.

During the next time period (15 to 60 seconds) let the ospreys try to catch some bass following the same rules, allowing any bass who are still alive to try to catch any remaining mayflies. Ospreys may *not* catch mayflies.

After this third round, have all the students gather in a circle and bring whatever bags they have captured. Ask the students to empty their bags and count the number of white and the number of colored food pieces they have. Make a list of the remaining mayflies, bass, and the ospreys on the board or on a large piece of paper and write down how many white and how many colored food pieces each had in the end.

Explain that the colored food pieces represent an insecticide that was washed into the river. Discuss what insecticides are used for and explain that this particular one does not break down into another substance quickly, but stays in the environment and is passed from one organism to another.

Since mayflies are insects which are affected by this particular insecticide, any mayfly which survived through all three rounds, but which had even one piece of colored food in its stomach is now *considered dead*. Any bass which had more than half of its stomach contents in colored food pieces is also considered dead. The ospreys will not die at this time, but when they lay eggs, the shells will be so thin that the eggs will not hatch or the parents will crush the eggs when they try to incubate them.

Discuss this situation with the students. Help them see how the pesticide accumulated as it went up the food chain. One bass eats many mayflies, and one osprey eats many bass, so that a small amount of pesticide in many mayflies adds up to a large amount in a single osprey.

Ask the students to find out why we need pesticides. What are some of the tradeoffs (better crop yields, but unwanted effects on the environment) involved in using pesticides?

Discuss the kepone contamination of the James River that took place in Hopewell, Virginia. Point out that commercial fishing for some species is still banned for the lower part of the river and ask the students why the Virginia Health Department will not allow people to eat fish from that part of the James. Will *people* (who are at the top of the food chain) accumulate kepone in their bodies like the ospreys did in this activity?

Have students see if they can find out about some alternatives to using toxic substances to kill insects that eat crops.

Whenever a pesticide is sprayed on a population of insects, there are always a few which are not killed by it —they are *immune* to its effects. The offspring of these individuals are more likely to be immune also to the pesticide and eventually these "superbugs" outnumber those which can be killed by a certain pecticide. What effect does this change in the insect population have on man's efforts to control it? See if you can find out what kinds of insects have created this kind of a problem (cockroaches are a good example of insect resilience).

Give the students the following information and have them respond to the questions:

An ecologist studied the presence of a toxic chemical in a river. He found the water had one molecule of the chemical for every one billion molecules of water. This is called one part per billion (1 ppb). The algae had one part per million (1 ppm) of the toxic chemical. Small animals, called zooplankton, had 10 ppm. Small fish had 50 ppm. Large fish had 100 ppm. How do you explain the increase in this toxic chemical to 100 ppm for the large fish? Use a drawing to help support your answer.

The ecologist found the chemical was a pesticide which had been sprayed on cropland 10 miles away from the river. How did so much of it get into the river? What might be done to prevent this kind of contamination in the future?

This activity was adapted from "Deadly Links," *Project WILD Elementary Activity Guide*, Western Regional Environmental Education Council, 1983. Contact the Virginia Commission of Game and Inland Fisheries (Game Commission), 4010 West Broad Street, Richmond, Virginia 23230, 257-1000 to find out more about Project WILD.

Science and Social Studies

SOL:
Science 4.2, 4.14, 4.15, 6.2, 6.14, 6.16, 6.20, 7.1, 7.18
Social Studies 6.3, 8.8, 9.6, 9.8

Ia, Ib, IIb, IIc, IId, IIe, IIId, IVa

Skills: observing, making inferences, predicting

TOXIC TROUBLES

Objectives The students will (1) predict the extent of the area affected by a simulated toxic waste spill in a stream or river, and (2) make inferences as to how such a pollutant might affect the water ecosystem.

Method Students will take a field trip to a stream or river and use popcorn to simulate a toxic waste spill.

Background Because the water in a river is always moving, anything added to the water has the potential for extended impact as it is carried downstream. While it is true that pollutants become more and more diluted as they move and mix with greater amounts of water, "Dilution is NOT the solution to pollution." Many toxic substances can affect living organisms even when their concentration may only be a few parts per billion (ppb).

To illustrate the concept of concentration, fill a ten gallon aquarium with water and add one drop of food coloring. This one drop represents one *part per million* (ppm). Ten thousand gallons of water with one drop of food coloring would represent one *part per billion* (ppb).

In 1975, serious contamination of the James River occurred when the pesticide *kepone* was spilled in the river at Hopewell through careless manufacturing processes. (See the activity POISON IN THE FOOD CHAIN for more information about the kepone incident). Over a decade later, kepone persists in the lower James, affecting the organisms which live there.

Oil is a toxic substance which harms the environment when it coats the feathers of water birds, seeps into the eggshells of birds and other animals, covers plants and prevents photosynthesis, and enters the digestive tract of animals. Other toxics may not be as visible as an oil spill, but can be equally deadly. Sometimes the chemicals are directly ingested by fish and other water-breathing organisms, and sometimes they are absorbed by plants and plankton in the water which are in turn eaten by larger animals.

It is extremely difficult to clean up toxic spills in a river because the chemicals tend to be widely dispersed by the current. Even after much of the substance has settled to the bottom sediments (as much of the kepone has) the cost to dredge the bottom to get rid of it would be tremendous. That doesn't take into consideration the fact that if one *did* dredge, it would be difficult to find a place on land to dump the dredge "spoil" so that it would not get back into the aquatic ecosystem through filtration into the surface and ground water again. In addition, when dredging is done, the contaminated sediments are inevitably mixed, and some of the toxic substance is released into the water again, directly affecting the organisms with which it comes in contact.

Obviously the best solution is prevention of such spills. Legislation such as the Clean Water Act of 1977 regulates what can be discharged into water. Agencies such as the Virginia State Water Control Board are charged with enforcing the regulations. (See the activity called INFORMATION PURSUIT to find out more about regulations and agencies responsible for Virginia's rivers.)

For more information about toxic chemicals in water, see pp. 12-15 in the "Getting Acquainted with Nature: Our Fresh Water Resources" booklet contained in this guide.

Materials 4-5 gallons of popped corn (You might be able to get some stale popcorn from a movie theater. If that is not possible a 2 pound bag of popcorn kernels will make as much as you need—do *not* add salt or butter!)

Procedure Go to a stream near your school or to a shallow part of the James River where there is a reasonably strong current flowing. If you are going to the James River, call 804-226-4423 shortly before the trip to get a report on the water level as measured at the Westham gauge. If the water level is above 6.0 feet, it would be advisable to postpone your trip. Life jackets are recommended if you are taking students to the James River. They can be borrowed from the James River Park naturalist. Call 231-7411 for more information.

Depending upon your site, you can divide the class into small groups, giving each two quarts of popcorn, or you can use all of the popcorn at once and do the activity as a large group. Small groups work better if you are in the Fall Zone of the river where groups of students can spread out over the rocks and each group can do the activity so that the popcorn will not flow into that of another group.

Explain to the group that they are supposed to be environmental managers in a park (such as the James River Park) where there has been a toxic chemical spilled into the water. Their job is to determine the impact of the toxic substance on the organisms in the river and help decide what to do about it.

The popcorn will represent the chemical and anything it touches will have the toxic substance in or on it.

Before you toss the popcorn into the water, have the students observe the currents, wind, rocks, etc. to see if they can *predict* where the toxic substance (popcorn) will go when it enters the water. Once they have had a chance to predict, give each group some popcorn or use the whole amount at once and throw it out into the current. If there is any breeze at all, you will need to wade out into the water a little way and drop the popcorn rather than throw it.

Much of the popcorn will probably stay on the surface at first. However, if the current is rather slow, you will observe that the popcorn eventually sinks to the bottom, as any toxic substance (even oil) would, affecting more organisms than at first.*

Ask students to observe carefully where the popcorn travels and discuss the following questions:

Were any plants affected by the spill?

Were some plants hit harder than others? Why?

Were any animals touched by the substance?

Could some animals escape if they wanted to (or if they knew the poison was in the water)?

Since birds can fly (and thus get away from an oil spill), why are they often coated with oil at a spill site?

Which kind of animal would be most affected?

How would animals that eat aquatic plants be affected?

What influence do you think such a spill would have on humans (fishing, boating, swimming, drinking water, etc)?

How might a spill such as this be cleaned up?

Who do you think should be responsible for clean-up?

How could an accident like this be prevented?

How did the kepone accident at Hopewell, Virginia, in 1975 affect the organisms that live in the James River?

**NOTE TO THE TEACHER*—Please discuss with the students the difference between conducting this science experiment and throwing food left over from a picnic into the river. Consider the visual impact alone if everyone who went to the river left food behind. Although food is biodegradable (it breaks down quickly), it adds nutrients to the water and contributes to the problem discussed in the activity called TEMPERATURE AND DISSOLVED OXYGEN.

Science

SOL: 6.2, 6.20, 7.1, 7.2, 7.5, 7.16, 7.18
8.1, 8.3, 8.4, 8.5, 8.17

IIb, IIIc, IIId

Skills: observing, measuring, making inferences, predicting, gathering data

TEST THE WATERS

Objectives The student will (1) conduct one or more tests on several samples of water from a river or stream, and (2) make inferences as to the quality of the water and the possible source of any problems identified.

Method Students will use water quality test kits to conduct tests for any or all of the following parameters: dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, temperature, total phosphorus, nitrates, turbidity, and total solids.

Background The Virginia State Water Control Board has the responsibility of enforcing the laws which deal with water quality in the Commonwealth. This Board regularly tests the water at many locations in each of the major river basins of the state. It determines whether or not various segments of river meet the "fishable-swimmable" criteria established by the federal Clean Water Act and it sees if the water is in compliance with Virginia's Water Quality Standards. There are 118 water quality monitoring stations in the James River Basin which test temperature, dissolved oxygen, coliform bacteria, pH, metals, and organic pesticides.

There are two resources provided with this activity guide to help explain how and why various water quality tests are conducted. The first is a booklet found in the pocket of this guide called "Getting Acquainted with Nature: Our Fresh Water Resources." The first part of the booklet describes both the natural and the man-made conditions that can be found in our rivers. Beginning on p. 39 are descriptions of how to measure pH, turbidity, dissolved oxygen, temperature, nitrogen, hardness, and conductivity in water.

The second resource is a *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools*, which can be found in the kit accompanying this guide located in the central office of your school division. This manual is designed around the Water Quality Index developed by the National Sanitation Foundation. Nine water quality parameters constitute this index: dissolved oxygen, fecal coliform, pH, biochemical oxygen demand (5-day), temperature, total phosphorus, nitrates, turbidity, and total solids. Water quality results from the nine parameters are used to calculate an overall water quality index which is a single number representing river water quality at the sampling area. The index is useful for monitoring changes in river water quality over time, comparing water quality of different river stretches, and comparing water quality of different rivers.

The manual gives careful descriptions for collecting water samples, running the water quality tests, analyzing the data collected, deriving an overall index, drawing appropriate conclusions about water quality, and identifying probable sources of any water quality problem found.

Materials water quality test kits

A list of water/wastewater test kit suppliers can be found in the back of the "Getting Acquainted with Nature" booklet.

The descriptions in the *Field Manual for Water Quality Monitoring* are for use with Hach Equipment Company and Millipore Company water test kits. Exact descriptions, prices, and addresses are listed in the manual.

Kits for testing pH and dissolved oxygen can be borrowed from the James River Park naturalist if you plan to take your class to that section of the James River for this activity.

Procedure Use the booklet or the manual described above and have your students conduct as many of the tests as possible using water from the James River or one of its tributaries.

If you are going to the James River, call 804-226-4423 shortly before the trip to get a report on the water level as measured at the Westham gauge. If the water level is above 6.0 feet, it would be advisable to postpone your trip. Life jackets are recommended if you are taking students to the James River and they can be borrowed from the James River Park naturalist. Call 231-7411 for more information about life jackets and test kits.

Ask students to discuss the results they get and the effect that high or low readings have on aquatic life and on humans who use the river for drinking water, fishing, or recreation.

If there are unfavorable results in any of the tests you conduct, ask the students to use what they know about the point and nonpoint sources of pollution upstream from their sampling point to infer what might be the source of the problem(s).

Extension Scientists are becoming concerned about the fact that the pH level of many bodies of water seems to be getting "lower," and that rainwater itself in some areas of the world is highly acidic. This so-called "acid rain" can cause severe damage to buildings, outdoor sculpture, plants, and water-dwelling organisms.

Ask the students to find out more about "acid rain" or acid precipitation. What causes it? In what areas of the United States or the world is it becoming a concern? Does everyone agree that it is a problem? What are the different points of view on this issue and what factors (such as economic considerations) influence people's perceptions? If it truly is a problem, what can be done about it?

WATER WE DOING TO OUR WATER?

Science and Social Studies

SOL:
Science 4.2, 4.15, 6.2, 6.20, 6.21
Social Studies 5.8, 7.5, 8.4, 9.6, 9.8, 9.9

Ia, IIa, IIb, IIc, IId, IIIa, IIId

Skills: making inferences, gathering data, experimenting

Objectives The students will (1) identify the source of their home and school water supply, and (2) know some methods of purifying water including treatment with alum, filtration, and chlorination.

Method Students will use community resources to investigate the source of their drinking water and attempt to clean muddy water using two different methods.

Background Clean drinking water is crucial for our survival. For many years people did not realize that water could contain bacteria and viruses which cause disease and death. Epidemics which killed thousands of people in the past were often caused by impure drinking water. Besides bacteria and other microscopic organisms, water can contain dirt and chemicals which make it unpleasant or unhealthy to drink.

Water in our homes and schools comes either from private wells or from a municipal treatment plant which takes water from a well, lake, river, or reservoir. You can find out more about the process which water treatment plants use to clean drinking water on pp. 9-11 in the *Be Water Wise* booklet found in this guide. Be sure to read not only these pages, but the rest of this booklet as well for lots of useful information about water supply, water pollution, and water (and energy) conservation!

Lynchburg was the first community along the James to use the river as the source of its drinking water. In 1830, the town hired a Prussian engineer, Albert Stein, to design a public waterworks and the entire town turned out to see the clean water gushing from the pipes. Later the city of Richmond hired Stein to perform what at the time seemed to be a miracle for the capital, too. Unfortunately, since people had been clearing the virgin forests in the James River basin for 100 years, soil erosion after each rain had become a major problem. The river water was extraordinarily muddy by the time it reached Richmond. Stein designed two filtration systems (the first in the country) to get rid of the sand, gravel, and mud, but neither of them worked very well. Servants in Richmond homes often were ordered to swish bags of alum in the family water supply to help settle out the mud. As it turned out, Stein's methods were correct, his equipment just wasn't extensive enough to handle the quantity of water and mud that needed to be treated. Unfortunately the river water isn't any less muddy today than it was 150 years ago, but we do have better methods of cleaning it up before it reaches our homes.

The present-day municipal water treatment plants in the greater Richmond area are listed below along with their addresses and phone numbers. You can make arrangements to take a class to your treatment plant for a field trip or you can call and get answers to specific questions you may have about the purification processes used to clean your drinking water.

Richmond Water Treatment Plant
(serves the city of Richmond, Henrico County, and portions of Hanover and Goochland Counties)
3920 Douglasdale Road
Richmond, Virginia
780-6286

Swift Creek Water Treatment Plant
(serves portions of Chesterfield County)
13400 Hull Street Road—near U.S. 360 crossing of Swift Creek Reservoir
744-1345

Appomattox River Water Authority
(serves portions of Chesterfield County, Colonial Heights, Petersburg, and Dinwiddie County)
21300 Chesdin Road—off Route 36 near Matoaca
1-590-1145

Some portions of Chesterfield County and many areas in Hanover are served by public water supplies which are drawn from wells and do not require extensive water treatment facilities since well water has been filtered naturally through the soil.

Many water treatment plants (including the one for Richmond City) used to dispose of the sludge which accumulates after it has been filtered from the water by pumping it back into the river. However, because the sludge contains the alum used to help dirt particles stick together and settle to the bottom, regulations in the Clean Water Act prevent treatment plants from putting it in the river again. Therefore, sludge is often simply pumped into lagoons close to the plant. This becomes a problem when the lagoons are filled to capacity. There really hasn't been a satisfactory solution to this problem yet.

In addition to filtering out the dirt, all of the Richmond area water treatment plants (and most others as well) add chlorine to the water some time during the purification process to kill any bacteria or other organisms present. Many (including the Richmond area plants) also add fluoride for dental health. Some plants also add lime to the water to help prevent rust in pipes.

Sometimes Mother Nature presents problems over which we have little control, however. In September of 1981, the James River turned bright green for almost fifty miles between Richmond and Scottsville. The culprit was blue-green algae which bloomed as a result of warm weather, low water which backed up behind the dams of Richmond (forming what amounted to stagnant ponds), and nutrients from fertilized fields upstream. Fortunately, the algae released only odors as they died and no toxins which could be harmful for those drinking the water. The city spent thousands of dollars adding tons of activated charcoal to the water filters at the treatment plant and chemists tested the water day and night, but the odor and unpleasant taste remained for a couple of weeks until rain and cold weather cleared the water.

People with private wells can ask the local Health Department to take a sample of their water to test for bacteria. If a private well is found to contain bacteria, homeowners are instructed to pour household chlorine bleach into their wells to kill the organisms. It is possible to test wells for chemicals and other contaminants, but it is not always easy to identify where they are coming from and eliminate the problem. The Health Department will also test for the presence of fluoride in well water, which occurs naturally in some places in Virginia and helps prevent tooth decay.

Historical information taken from Ann Woodlief, *In River Time: The Way of the James* (Algonquin Books of Chapel Hill, 1985), pp. 122-124 and 192.

Materials

ACTIVITY A—large container of dirty water (add soil and/or debris to tap water and stir); 2 pint jars, glasses, or beakers; aluminum sulfate (alum)—you can buy a small jar in a drug store or in the spices section of a grocery store

ACTIVITY B—dirty water left over from Activity A, 1 gallon plastic milk jug or 2 liter soft drink bottle, piece of wire mesh (screen) or cloth, fine sand, coarse sand, and gravel, clear container with tap water in it

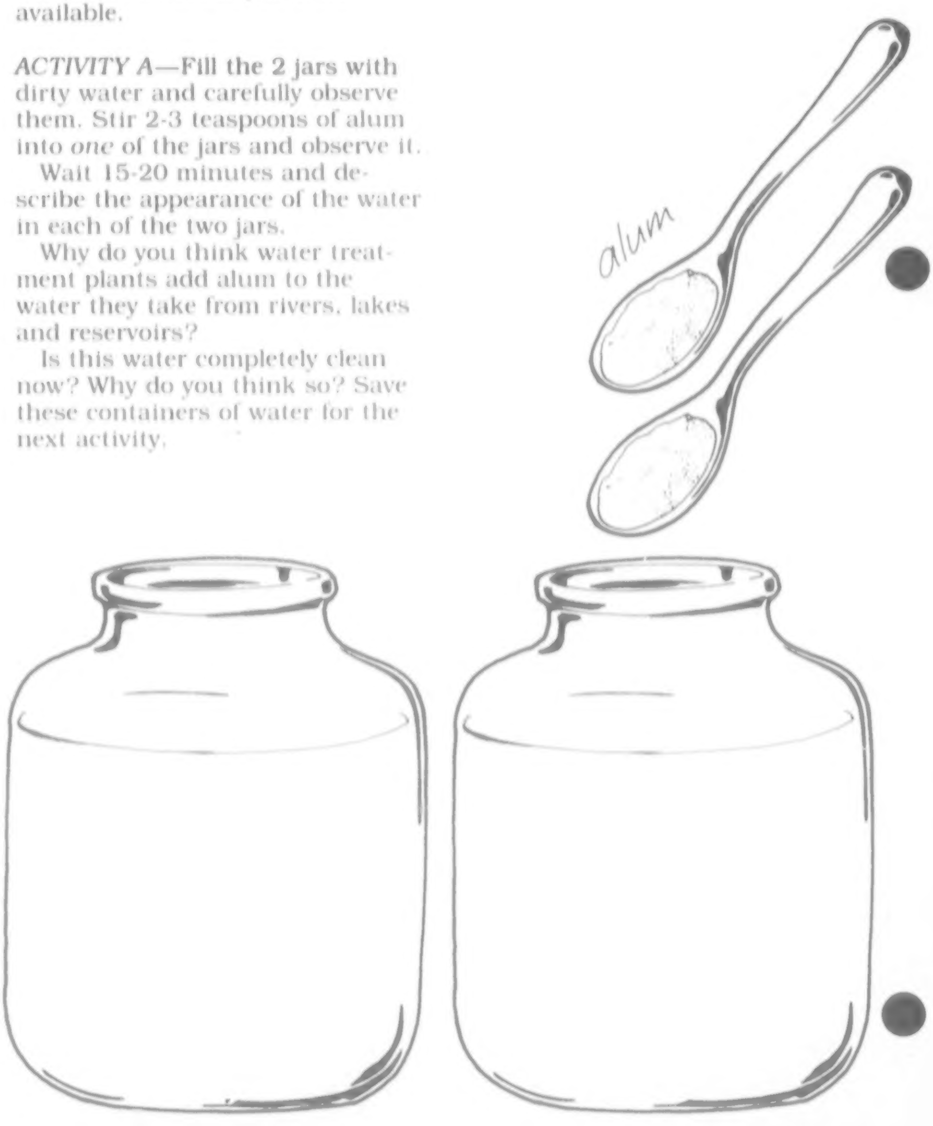
Procedure There are many ways to set up filters to simulate one of the processes used to purify water. A couple of methods are suggested in this activity, but use whatever materials you have available.

ACTIVITY A—Fill the 2 jars with dirty water and carefully observe them. Stir 2-3 teaspoons of alum into *one* of the jars and observe it.

Wait 15-20 minutes and describe the appearance of the water in each of the two jars.

Why do you think water treatment plants add alum to the water they take from rivers, lakes and reservoirs?

Is this water completely clean now? Why do you think so? Save these containers of water for the next activity.



ACTIVITY B—Cut the plastic jug or bottle in half (the top half will be your water filter). Put the piece of wire mesh or cloth inside the neck with the top pointing down. Add layers of fine sand, coarse sand, and gravel.

Hold the filter you have just made over the bottom half of the jug or bottle (this serves as your catch basin). Pour some clean water through the sand and gravel to "prime" the filter. Discard the clean water that passes through the filter.

Again, observe the water in the two jars from Activity A. Then pour the water treated with the alum into the filter being careful not to pour out the *sludge* that collected in the bottom of the jar. Collect the filtered water in the bottom half of the jug.

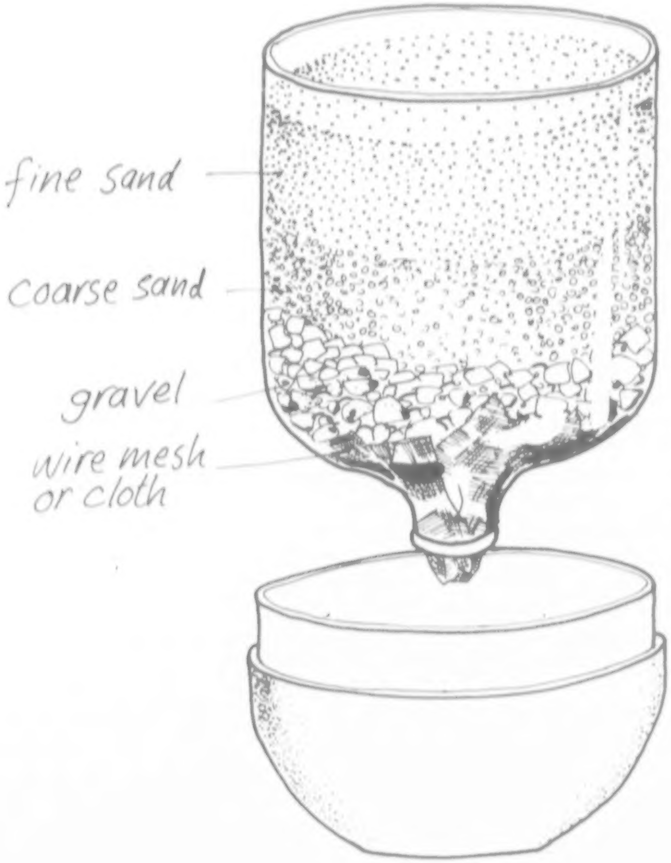
Compare the appearance of the filtered water with some tap water in a clear container. Is the filtered water safe to drink yet? Why or why not?

What would you do to get it cleaner? Save a little from the first filtering to use as a comparison and then try pouring the rest through your filter several times to see if it gets any cleaner.

Water treatment plants add chlorine to the water after it has been treated with alum and filtered several times. Why do you think chlorine is used?

Some treatment plants also add lime and fluoride to their water. Find out what each of these materials is supposed to do.

ACTIVITY C—Ask the students to check with their parents or guardians and see whether the water in their home comes from a private well or from a municipal treatment plant or well. (Do they have to pay the city or county a monthly water fee?) Have the students answer the questions on p. 16 of the "Be Water Wise" booklet if the water in their home comes from a municipal treatment plant. If their source of water is a private well, the questions on p. 17 are more appropriate.



Extension The following activity can be used to illustrate the filtration that takes place naturally in the ground before water flows into private or municipal wells.

Make another filtering apparatus like the one you made for Activity B. This activity is easier if you use two 2-liter soft drink containers with the bottom cut off rather than a gallon milk container. In *one* filter put just about 1-2 inches of sand and gravel. In the second put sand and gravel to within about 3 inches of the top of the filter and then put a layer of sub soil and on top of that a layer of top soil. Again "prime" the filters by pouring clean water through each and discard the clean water that comes out the bottom.

Pour equal amounts of equally dirty water into each of the two filters. Compare the appearance of the water that filters out at the bottom.

Would you rather drink water that has only filtered through a few inches of soil or some that is taken from a well that is 50 feet deep? Why?

Another activity you could try is to mix one liter of tap water with 100 ml of saturated salt water *or* vinegar. Pour this mixture through one of your filters and smell or taste the filtered water to see if the salt or vinegar was removed by the filter. These substances can represent pollutants which are not easily removed from water.

Can you think of a way to purify water which contains salt? (It can be distilled—a process which involves boiling the water and then cooling the steam generated to cause it to condense back into liquid water in another container, leaving the salt behind in the original container.) Why don't cities near the ocean use this method to obtain their drinking water? (It is too expensive to be practical at this time.)

Science and Social studies

SOL:
Science 4.2, 4.15, 6.2, 6.17, 6.20, 6.21
Social Studies 5.8, 7.4, 7.5, 8.4, 9.2, 9.5, 9.6, 9.8, 9.9

Ia, IIb, IIc, IId, IIIa, IIId

Skills: gathering data, making inferences

DOWN THE DRAIN

Objectives The students will (1) know whether the wastewater from their home goes into a septic tank or a municipal treatment plant, (2) give a general description of the processes used to clean sewage, and (3) identify the eventual destination of their wastewater.

Method Students will use resource materials to find out the way in which the wastewater from their home is treated and ask their parents or community resource people for information about their system.

Background Unless the drainpipes in our house back up or there is a community problem (such as the flooding of the sewage treatment plants in Richmond and Chesterfield during the 1985 flood), most of us don't think about where our dirty water goes. Unless you have an outhouse, there are only two possibilities. Water from your drains goes to either a wastewater treatment facility or into a septic tank.

Two sources of information about sewage treatment have been provided for you. First, see pages 11-13 and 15 in the *Be Water Wise* booklet included in this guide for an explanation of how both wastewater treatment plants and septic systems clean our water.

Also see pp. 16-18 in the *Getting Acquainted with Nature: Our Fresh Water Resources* booklet contained in this guide for more information about decomposition of sewage.

In 1958, the city of Richmond began operating a primary sewage treatment plant located just downstream from the Fall Zone of the James River. It was not very effective, but it was the *first* wastewater treatment facility on the river. Presently there are 21 major municipal treatment plants in the James River Basin all the way from Covington and Clifton Forge to the nine facilities between Williamsburg and the Chesapeake Bay.

Below are the addresses and phone numbers of the sewage treatment facilities in the Richmond area. You can make arrangements to take a field trip to the one that serves your area, or you can call to get more information about how your water is treated.

Richmond Sewage Treatment Plant
(serves Richmond City, Henrico County, and a small portion of Goochland County)
Maury Street
Richmond, Virginia
230-1700

Chesterfield County

Falling Creek Sewage Treatment Plant
6137 Jefferson Davis Highway
Richmond, Virginia 23234
275-0063

Proctor's Creek Sewage Treatment Plant
1200 Coxendale Road
Chester, Virginia 23831
748-7322

In Virginia, community sewage treatment plants are operated by the local government (Board of Supervisors or City Council) whose members are elected by the people. The treatment plants are generally built and operated using both tax money and fees charged to the homes and businesses connected to the system. Sometimes partial cost grants are available for making improvements to the sewage treatment facilities but most of the funds must be raised by taking money from other programs in the local budget or by raising sewage bills or taxes. Usually none of these options is very popular with the constituents of the local government officials, so improvements are often slow to be made.

The Virginia State Water Control Board is charged with the responsibility of seeing that local governments meet state and federal regulations (set by the Environmental Protection Agency—EPA) regarding the quality of the water discharged by their sewage treatment plants. The State Water Control Board has the right to take a community to court and a judge can charge a fine of thousands of dollars a day if local governments do not comply with the regulations. Most of the time the EPA and the Water Control Board recognize the financial problems surrounding enlargement or improvement of sewage treatment facilities. They will give a community several years to raise the money to make improvements if the local governing body can show that it is trying to do what is necessary.

If we use less water in our homes, less wastewater has to be sent into a septic tank or to a wastewater treatment plant. Thus water conservation can save money both directly (less water = lower water and sewage bills) and indirectly (lower taxes for improvements to treatment plants). People with wells and septic tanks can save money through water conservation by using less energy (electricity generally) to pump water out of the well and by having to have their septic tank cleaned out less frequently.

The *Be Water Wise* booklet suggests many ways students and their families can conserve water in their home and save money in the process.

Procedure Help your students identify the destination of their wastewater once it leaves their house. Make a copy of the diagrams on pp. 12 and 15 of the *Be Water Wise* booklet and discuss the steps involved in cleaning sewage both in a wastewater treatment plant and in a septic

tank. Ask them to answer the questions on p.17 or p.18 of the booklet depending upon which kind of system serves their home.

Have the students do one or more of the following activities:

On the map included in this activity identify the location of the water treatment plant and the sewage treatment plant that serve your home and/or school (unless you have a septic tank system). Why do you think each is located where it is?

If your house has a well and a septic tank, draw a map of your yard and identify the location of each. (Ask your parents for help on this one.) Approximately how far apart are your well and septic tank? The Health Department has regulations concerning the distance they must be apart. Why do you think such regulations are necessary?

Find out what local, state, and federal governing agencies are responsible for operating and regulating your sewage treatment plant and the quality of the water it discharges into a stream or river. Where does the money to operate your facility come from?

How do you think conserving water in your home can help ease the job either your septic tank or your sewage treatment plant has to do?

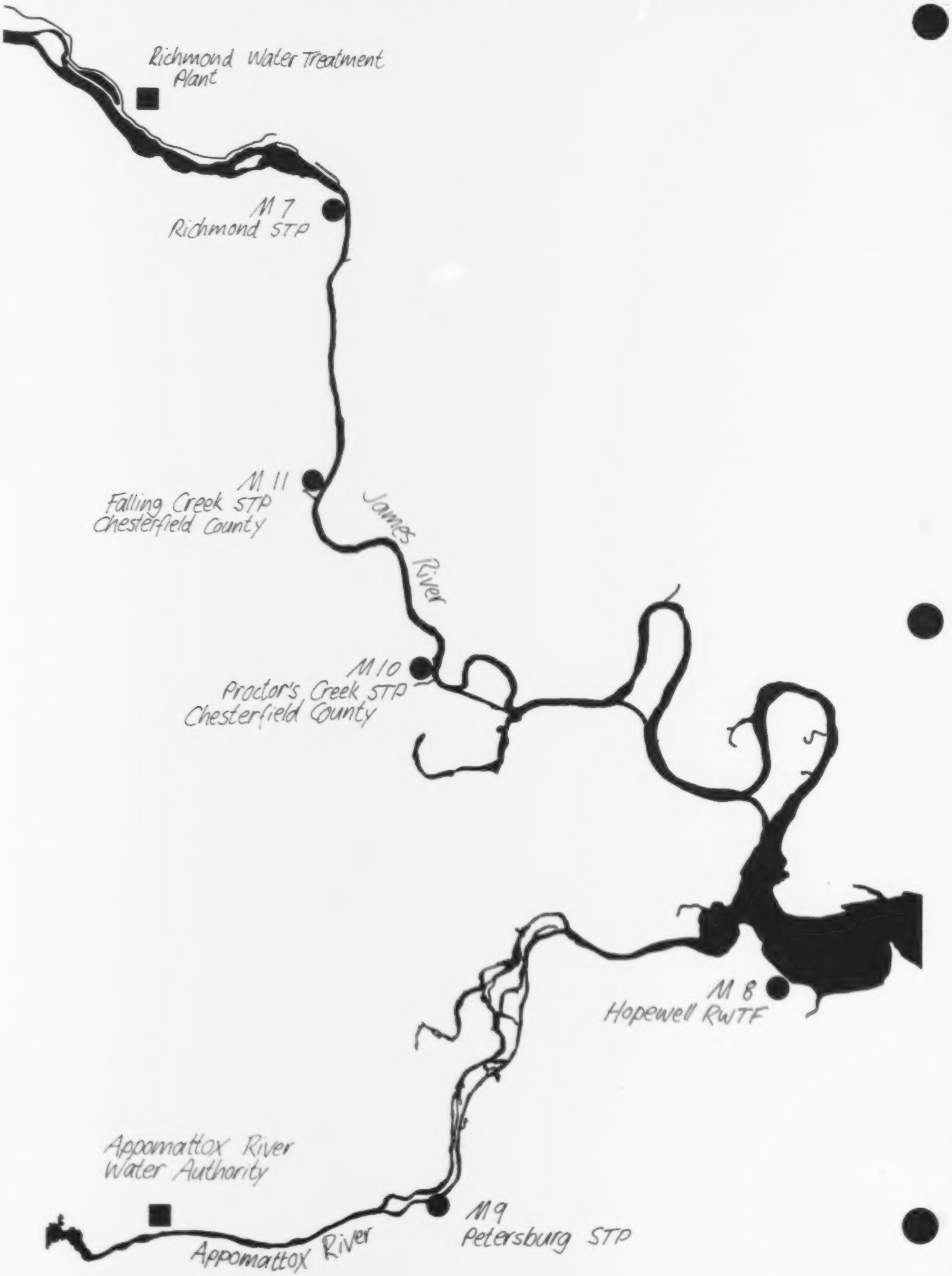
Identify at least four things that *you* can do to conserve water at home and at school.

Look around your house and make a list of the various toxic substances which end up being washed down the drain and into your septic tank or sewage treatment plant. For example, paint and paint thinner, silver polish, oven cleaner, ammonia cleansers, drain cleaner, bleach, disinfectants, floor wax, furniture polish and many other chemicals often go down the drain and end up in the environment (Even if they are thrown away in the trash and taken to the landfill, they still end up in the environment—often getting leached into the groundwater). How could you dispose of some of these substances to reduce their chances of getting into our water supply?

Most communities in the Richmond area (and elsewhere) use only primary and secondary treatment of wastewater before pumping it back out into the river or a stream. Tertiary treatment (advanced methods to remove traces of organic material and dissolved solids) is expensive and most local government officials don't want to raise taxes or sewage bills in order to install facilities for that kind of treatment. What do you think would happen if a law were passed which said that communities had to take their drinking water from a source *downstream* from their sewage treatment plant?

Many older communities (such as Richmond) have combined sewer systems which carry both sewage from homes and factories (sanitary sewers) and rainwater that runs off lawns and streets (storm sewers) into the sewage treatment plant. When there is a heavy rain more water comes through the pipes than the sewage treatment plant can handle and some of it is discharged directly into the river without being treated. What problems do you think this might cause? How could this problem be corrected? Why do you think communities don't just dig up all of the old pipes and put in new ones to separate the sanitary sewers from the storm sewers?

MAJOR MUNICIPAL DISCHARGES


Richmond Water Treatment Plant
M 7
Richmond STP
M 11
Falling Creek STP
Chesterfield County
James River
M 10
Proctor's Creek STP
Chesterfield County
M 8
Hopewell RWTF
Appomattox River
Water Authority
M 9
Petersburg STP
Appomattox River

Science and Social Studies

SOL:
Science 4.15, 6.20, 6.21, 7.18, 7.19
Social Studies 7.3, 7.5, 8.4, 9.5

IIb, IIc

Skills: researching and analyzing, gathering data

INFORMATION PURSUIT

Objectives The student will (1) identify some of the government agencies responsible for water management in Virginia, and (2) describe the activities of some private organizations which are involved with water.

Method Students will write letters or conduct research to find out the responsibilities and interests of various agencies and organizations involved with water management. They will compile a game of "Information Pursuit" to test their knowledge of these resources.

Background Water is a renewable resource meaning that it generally is not destroyed when we use it, but re-enters the environment to be recycled again and again. However, many human activities tend to contaminate water—sometimes for long periods of time.* Another problem is that we don't always have *enough* water for human needs in the areas where people are concentrated. Therefore, wise water management is necessary if we are to have enough clean water to meet our needs.

A number of federal environmental laws provide protection for both ground and surface waters. These include the Safe Drinking Water Act; Clean Water Act; Resource Conservation and Recovery Act; Toxic Substances Control Act; Federal Insecticide, Fungicide and Rodenticide Act; and Comprehensive Environmental Response, Compensation and Liability Act (superfund). Many federal programs relating to land use practices also affect management of the quality and quantity of Virginia's water resources. Some involve national parks and forests, federal reservoirs, wildlife refuges, wilderness areas, scenic rivers, wetlands, and soil conservation activities.[1]

The State Water Control Law was enacted by the General Assembly and provides for an "antidegradation" policy pertaining to state waters, including all water on the surface and underground. However, the Water Control Law does authorize new or increased discharges to high-quality water if it is demonstrated that such discharges are *justified for necessary economic or social development.* Any necessary waste treatment of the discharge is required by law where it is physically and economically feasible.[2]

A number of local, state, and federal government *agencies* are charged with a variety of responsibilities involving water management. Some of their duties overlap somewhat and others are very sharply defined. For example, the State Water Control Board is responsible for the administration and enforcement of the State Water Control Law. The State Health Department has responsibility for safe drinking water and other public health concerns related to water. The Virginia Commission of Game and Inland Fisheries deals with recreation and fishing in the fresh water resources of the state, while the Virginia Marine Resources Commission has responsibility for all salt water areas. The Virginia Institute of Marine Science conducts research and education activities regarding our marine resources.

The Scenic Rivers Act, passed by the General Assembly in 1970, provides for the protection of rivers or river sections of exceptional beauty. The process of including a river or river section into the system begins with studies by the Virginia Division of Parks and Recreation. After designation, no dam or other structure can be built that will impede the natural flow of the river. Preservation of stream banks and surrounding areas is required and development activities are restricted to assure the scenic river's "use and enjoyment" for its "recreational, geologic, fish and wildlife, historic, cultural, or other values."[3]

Other agencies are supposed to control what enters our water resources—the Virginia Soil and Water Conservation Commission and the Division of Solid and Hazardous Waste Management (part of the Health Department) for example.

There are also private organizations which have been formed for various purposes. Some are recreation or education oriented. Others consider themselves to be "watchdogs" to see that the government agencies do their jobs, or they are advocates for public support and concern for water resources.

Considering how important water is to our very survival, it is not at all surprising to find out how many agencies and organizations there are just in Virginia which are concerned with water management.

*see the activities called TOXIC TROUBLES, POISON IN THE FOOD CHAIN, SAVE THAT SOIL, NUTRIENTS AND WATER QUALITY, ROUND AND ROUND AND ROUND IT GOES, TEMPERATURE AND DISSOLVED OXYGEN, and DOWN THE DRAIN for more information about water quality.

[1] Sevebeck, Kahn, and Chapman, *Virginia's Waters* (Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, 1986) p. 39. [A copy of this booklet was sent to every school in Virginia—check the library for your copy]

[2] Sponenberg and Kahn, *A Groundwater Primer for Virginians* (Virginia Water Resources Research Center, VPI & SU, 1984) p. 14.

[3] Sevebeck, *Virginia's Waters*, pp. 39-40.

Procedure Have the students do one or more of the following activities:

Ask the students to find out more about some of the federal and state laws pertaining to water which are mentioned in the Background section.

You can also use the accompanying list of agencies and organizations as a resource for your students. The *local* offices of such agencies as the Health Department and the VPI Cooperative Extension Service can be found in your phone book. Have students look up information about various groups *or* ask them to write letters to find out the jurisdiction, purpose, responsibilities and/or information available from each one. Students could also find out which agencies are responsible for enforcement of which of the above laws.

Have a student contact the State Water Control Board and find out more about the following phrases in the Water Control Law: the law "authorizes new or increased discharges to high-quality water if it is demonstrated that such discharges are *justified for necessary economic or social development*. Any necessary waste treatment of the discharge is required by law where physically and economically feasible." Why were these phrases put into the law? Have individuals or localities ever used the "economic" factor as an excuse for an activity which would otherwise not comply with the law? How does the State Water Control Board determine whether economic problems are valid?

Another assignment could be to compare the different points of view of such groups as the Army Corps of Engineers versus the Coastal Canoeists or the Sierra Club; and the Environmental Defense Fund versus the Virginia Petroleum Council or the Association of Electric Cooperatives.

If you choose to have students write letters, use the following guidelines to avoid repetition and to get the type of information you want.

GUIDELINES FOR REQUESTING INFORMATION AND ASSISTANCE:

Be Specific Your chances of obtaining useful information will be greatly increased if you state exactly which materials you need, which issues interest you, or what questions you want answered. The "send everything you have" approach is uneconomical for the agency or organization and you will probably get nothing as a result.

Avoid Class-Wide Requests Limit requests for information from any single source to one or two students and pool the collected data. If you cannot avoid a situation where many students ask for similar information, send all the requests in one envelope and ask that materials returned be mailed in one package to one address.

Send a Self-Addressed, Stamped Envelope If you request material or information from volunteer organizations, include a self-adressed, stamped envelope. This will bring a quicker response because these organizations usually have very limited (or nonexistent) budgets and secretarial staffs.

Plan on Two to Three Weeks of Lead Time Again, limited staff and other responsibilities for both agencies and organizations often prevent immediate replies to requests.[1]

Once you have found out about some of these groups you might encourage students to organize a volunteer activity for one or more of them. For example, the naturalist at the James River Park could provide a number of suggestions for things students might do to help the park, from writing informational brochures (for older students) to picking up litter in the Park (for *all* ages!).

Another assignment could be to find out what sections of the James River have been designated as "scenic river." Are there attempts being made to have other sections so designated? How would "scenic river" status affect further construction or repair of existing dams in the Richmond area for such purposes as hydroelectric generation? Have there been any efforts along this line in the past?

A culminating activity for this section of study could be for students to use the information they have gathered to create their own version of Trivial Pursuit—"Information Pursuit." They can use index cards to write questions on one side with answers on the other.

Some examples for starters:

How can my family test our well water? (Health Department)
What kind of fish can I catch in the James River? (Game Commission)

Where can I find out how to conserve water in my home? (Virginia Water Resources Research Center)

Where can my family take our used motor oil? (Virginia Division of Litter Control toll free number 1-800-552-3831)

I think there is a chemical spill in the creek near our house. Who can I call about it? (Health Department—Division of Solid and Hazardous Waste Management)

[1] Guidelines adapted from PROJECT LEARNING TREE, The American Forest Institute, Inc, 1977. (Information about the PLT materials can be obtained from the Science Service, Virginia Department of Education, Box 6Q, Richmond, VA 23219, phone 225-2864)

AGENCIES

City of Richmond
James River Park
Riverside Drive & Hillcrest Rd.
Richmond, VA 23225
231-7411

Commission of Game and
Inland Fisheries
4010 West Broad Street
Richmond, VA 23230
257-1000

Council on the Environment
903 9th Street Office Bldg.
Richmond, VA 23219
786-4500

Department of Health
109 Governor Street
James Madison Bldg.
Richmond, VA 23219
786-3561

Department of Health
Div. of Solid and Hazardous
Waste Mgmt.
109 Governor St.
James Madison Bldg.
Richmond, VA 23219
225-2667

Department of the Army
Corps of Engineers
Fort Norfolk
803 Front Street
Norfolk, VA 23510
441-3601

Division of Litter Control
P.O. Box 241
Richmond, VA 23202
644-7884

Environmental Protection Agency
Chesapeake Bay Program
Liaison Office
839 Bestgate Rd.
Annapolis, MD 21401
(301) 841-5077 or (301) 224-2740

Environmental Protection Agency
Region III
6th and Walnut Streets
Philadelphia, PA 19106
(215) 597-9814

U.S. Dept. of Agriculture
Soil Conservation Service
Federal Bldg., Rm. 9201
400 North 8th St.
Richmond, VA 23240
771-2455

Virginia Cooperative
Extension Service
VPI & SU
Blacksburg, VA 24061
(703) 961-6705

Virginia Division of State Parks
1201 Washington Bldg.
Capitol Square
Richmond, VA 23219
786-2132

Virginia Historic Landmarks
Commission
221 Governor St.
Richmond, VA 23219
786-3144

Virginia Institute of
Marine Science
College of William and Mary
Gloucester Point, VA 23062
642-2111

Virginia Marine Resources
Commission
P.O. Box 756
2401 West Ave.
Newport News, VA 23607
247-2200

Virginia Soil and Water
Conservation Commission
203 Governor St.
Suite 206
Richmond, VA 23219
786-2064

Virginia State Water
Control Board
P.O. Box 11143
Richmond, VA 23230
257-0056

Water Resources Research Center
VPI & SU
617 North Main St.
Blacksburg, VA 24060
(703) 961-5642

100

ORGANIZATIONS

Chesapeake Bay Foundation
11 South 12th Street
Suite 314
Richmond, VA 23219
780-1392

Coastal Canoeists
P.O. Box 566
Richmond, VA 23204
262-0964

Conservation Council of
Virginia Foundation
P.O. Box 106
Richmond, VA 23201
232-3991

Environmental Defense Fund
Virginia Project
11 South 12th Street
Suite 314
Richmond, VA 23219
780-1297

Falls of the James Committee
7751 Rockfalls Drive
Richmond, VA 23225
786-0494

Float Fishermen of Virginia
Box 683
Appomattox, VA 24522
352-8229

Izaak Walton League of America
Virginia State Division
701 Sandusky Drive
Lynchburg, VA 24502
239-1874

Lower James River Association
P.O. Box 100
Richmond, VA 23201
730-2898

National Association of
Conservation Districts
Virginia Association of Soil
& Water Conservation Districts
P.O. Box 246
Stanardsville, VA 22973
985-2759

Nature Conservancy
Virginia Field Office
619 East High Street
Charlottesville, VA 22901
295-6106

Richmond Renaissance
600 East Broad Street
Richmond, VA 23219
644-0404

Richmond Whitewater, Inc.
P.O. Box 61011
Richmond, VA 23261

Sierra Club, Virginia Chapter
Falls of the James Group
4017 Dunston Ave.
Richmond, VA 23225
231-7411 or 232-0674

Virginia Anglers Club
P.O. Box 4945
Richmond, VA 23229
794-8266

Virginia B.A.S.S. Federation
1402 Pump House Drive
Richmond, VA 23221
358-0143

Virginia Chamber of Commerce
611 East Franklin Street
Richmond, VA 23219
644-1607

Virginia Clean Water
Action Project
11 South 12th Street
Suite 216
Richmond, VA 23219
649-9075

Virginia Environmental Endowment
P.O. Box 790
Richmond, VA 23206
644-5000

Virginia Farm Bureau Federation
200 West Grace Street
Box 27552
Richmond, VA 23261
225-7535

Virginia Forestry Association
1205 East Main Street
Richmond, VA 23219
644-8462

Virginia, Maryland & Delaware
Association of Electric
Cooperatives
P.O. Box 15248
5601 Chamberlayne Rd.
Richmond, VA 23227
264-2801

Virginia Petroleum Council
1809 Staples Mill Rd.
Richmond, VA 23230
353-0141

Virginia Solid Waste Commission
P.O. Box 3-AG
Richmond, VA 23208
786-4169

Water Pollution Control
Federation
Virginia Office
8207 Franconia Rd.
Richmond, VA 23227
266-6415

Science and Social Studies

SOL:
Science—4.15, 6.20, 7.18, 7.19
Social Studies—7.3, 7.4, 7.7, 7.9, 8.1, 8.7, 8.9, 8.10, 9.5, 9.6, 9.10, 9.11

IIb, IIc

Skills: researching and analyzing, gathering data

JAMES RIVER GAZETTE

Objectives The students will (1) research and write a newspaper article or column, (2) identify a diversity of issues related to the James River, and (3) formulate their own opinions concerning controversial issues.

Method Students will research, write, and produce a newspaper that features information about the James River.

Background Newspapers are one of our major sources of information regarding current events and issues as well as historical reflections. The production of a newspaper requires a wide array of skills which should be able to take advantage of various talents students possess.

This could be used as a culminating activity to the study of the James River both past and present. Students should use all of the information they have learned to compile a newspaper featuring the James River. The paper could include some of the products of the class activities.

Materials library resources, typewriters, cameras and tape recorders, computers with word processing and graphics software (optional)

Procedure Using an actual newspaper as a model, discuss the various parts of a typical paper. Point out the editorials, letters to the editor, political cartoons, special sections, and series articles in addition to the regular news articles.

Ask the students to choose one type of section for which they would like to produce an entry relating to the James River. If research is necessary to gather information about their topic, assist the students in finding appropriate sources. Try to set the stage for both serious and creative/humorous reporting.

Some suggestions for consideration are as follows:

EDITORIAL PAGE

views for and against (a) the proposed flood wall, (b) the ban on phosphate detergents, (c) fish ladders over the dams,

letters to the editor from (a) an upstream farmer who feels he is being asked to do more than his share for river clean-up, (b) the owner of a canoe and raft rental company regarding the effluent from the sewage treatment plant and its unpleasant effect on his business

kepone—still present in the James after 12 years

recovering from the flood of November 1985

INTERVIEWS WITH:

a present industrial water user such as Virginia Power, James River Paper Corporation

a senior citizen who remembers the spring shad and herring runs of the past

a bateau builder or a member of the Virginia Canals and Navigation Society to see what each might have learned about the history of the river

a parent to find out how citizens think of the river—as a barrier to travel, a recreational site, etc.

a member of an environmental group such as the Sierra Club to find out club concerns about the river

FEATURES

report of the scientific tests conducted by the students (TEST THE WATERS activity)

report on the critters collected or pictures of the "crazy critters" designed by the students

"The Way It Was"—an historical account of some aspect of the river in the past (discovery of the falls, flour mills, development of the iron industry, building the Kanawha Canal, plantation life)

recreation—advertisements featuring sports equipment and guided trips down the river

description of the methods of construction used for the new Lee Bridge

description of the geologic features of the Fall Zone

cartoons—Garfield at Jamestown

recipes for fish or other products of the river

"Dear Aunt Belle" advice column—a sturgeon who wants to go home, a fish that can't breathe

horoscope—predict the future of the river

Activity adapted from "Aquatic Times", *Project WILD* (Western Regional Environmental Education Council, 1986). Find out more about Project WILD in Virginia by contacting the Commission of Game and Inland Fisheries, 4010 W. Broad St., Richmond, VA 23230, phone 257-1000.

SAVE THE RIVER SIMULATION

Science and Social Studies

SOL:
Science 6.4, 6.20, 6.21, 7.5, 7.6, 7.18, 7.19, 9.3
Social Studies 6.2, 7.5, 7.8, 7.9, 8.1, 8.2, 8.4, 8.7

IIb, IIc, IId, IIe, IIIc, IIId, IIIe, IIIf, IIIg

Skills: gathering data, questioning, communicating

Objectives The student will (1) state that the James River is a resource needed by many and varied groups, (2) generalize that care and planning for the use of this resource is necessary in order to have optimum benefits for all, and (3) explain that political and economic factors often influence decisions regarding the environment.

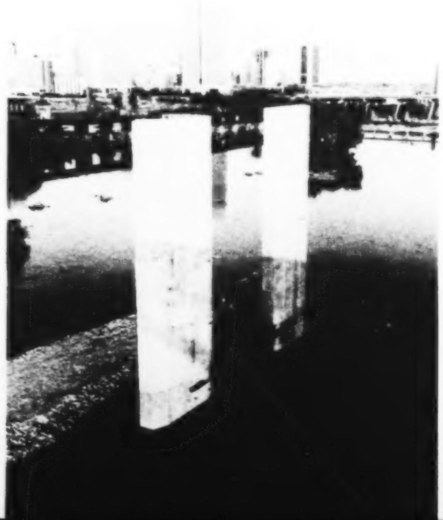
Method Students will participate in a simulation in which they use their influence by voting for one or more policies regarding the management of the James River.

Background Clean fresh water is a renewable but limited resource. There are many demands on the water in our rivers and these often conflicting demands must be weighed against each other to determine the maximum benefits to be derived from this vital resource.

Often in simulations of this type, students find that the policy passed is not the most important or the most pressing one, but one which simply has the fewest opponents. Compromise and the give and take of policy decisions are illustrated very well in this activity.

Procedure This should be done as a culminating activity after students have studied several of the problems and issues surrounding management of the river. After assigning roles and letting students read the policies, you may want to give them time to do a little more research so they can have as much information at their disposal as possible in order to make wise choices.

Stress that students should vote according to the wishes of their interest group—not according to their own personal feelings about the policies.



SAVE THE RIVER A Simulation

In this simulation each student will be a member of one of seven interest groups that use their "influence" (points) to establish policy regarding the management of the James River. Each interest group has an equal number of points to allocate. The interest groups are:

(1) Chamber of Commerce
(2) Metropolitan Area Local Governments
(3) Farmers' Forum
(4) Environmental Concern Groups
(5) Recreational Users Group
(6) Taxpayers' Association
(7) State and Federal Agencies

The simulation will be divided into three time periods. They can last from 15 minutes to 45 minutes or more for each one depending upon the age and involvement of the students. During *each time period, each group* will have *100 points* to allocate to any or all of the five policy choices. Each group may assign *negative* points to any of the policies if they choose, but the absolute value (disregarding the positive or negative sign) of all points for one interest group must be 100 for each of the three rounds.

At any time participants can: (a) talk with any member of their group, (b) communicate with members of any other group, or (3) conduct conferences with other groups.

The following pages briefly describe each of the five policies under consideration and tell which groups favor, oppose or are neutral to each policy and why they feel that way. The points for each policy are *cumulative* for the three rounds. In order for any policy to be implemented, it must receive a total of *500 points at the end of round 3.*

At the end is a list of the actual agencies and organizations which might be a part of one of the seven interest groups. You could consider having one student contact each group to find out how the real world counterparts feel about each of the five issues.

POLICY 1 Require that all waste water treatment plants and industrial sites in the James River basin use tertiary treatment processes to reduce their nitrogen, phosphorus and toxic chemical discharge into the river and its tributaries.

Favor Tertiary treatment would provide cleaner water for the communities downstream which use the river as a source of drinking water, food, or recreation. Less nitrogen and phosphorus reduces the incidence of algal blooms, low dissolved oxygen, and other problems associated with nutrient increases. Thus cleaner water would be better for the fish and other organisms in the river. Reduction of nutrients would also allow submerged aquatic vegetation (SAV) to return to the lower James and the Chesapeake Bay and thus provide cover and spawning areas for fish, crabs, oysters, etc. Legislation of this type could reduce the pressure on farmers to control their fertilizer run-off.

Environmental Concern Group
Recreational Users Group
State and Federal Agencies
Farmer's Forum

Oppose Tertiary treatment of waste water is very expensive. Such a requirement could discourage new industry and cause a financial burden for existing industry. It also places an added strain on the budgets of local governments and may require property tax increases or higher water and sewer bills for individuals (who *elect* the members of City Council and the Boards of Supervisors. . . .)

Chamber of Commerce
Metropolitan Area Local Governments
Taxpayers' Association

104

POLICY 2 Require a reduction in non-point source pollution. Farmers would be required to plant buffer strips along waterways and use all other best management practices (BMPs) to eliminate soil erosion and nutrient run-off from agricultural lands. Developers and highway construction contractors would be required to increase their soil erosion measures.

Neutral

Taxpayers' Association

Favor Buffer strips, best management practices, and extra soil erosion prevention would help reduce the amount of sediment flowing into rivers. Sediment causes harmful conditions for aquatic organisms and also fills in shipping channels requiring frequent dredging to keep them open. Buffer strips and BMPs also reduce the amount of nitrogen and phosphorus run-off from farmlands with the associated advantages mentioned in the FAVOR section of Policy 1.

Environmental Concern Group
Recreational Users Group
State and Federal Agencies

Oppose Planting buffer strips takes land out of crop production and therefore cuts into farmers' already slim profits unless the government is willing to pay the farmers for instituting this practice. Rural governments see this as a threat to the livelihood of farmers—a major portion of the elected officials' constituency. Extra expense for developers and contractors could discourage economic development.

Farmers' Forum
Metropolitan Area Local Governments
Chamber of Commerce

POLICY 3 Build a flood wall along the James River in downtown Richmond to protect the businesses in the flood plain.

Neutral State and Federal Agencies (The U.S. Army Corps of Engineers is very much in favor of this project. Other state and federal agencies, however, are opposed to it.)

Favor The Shockoe Bottom area in downtown Richmond is flooded whenever the river rises significantly. Large floods, causing millions of dollars worth of damage have occurred in recent memory in 1969, 1972, and 1985. The susceptibility to flooding is discouraging business growth in this area which is rapidly being revitalized. A flood wall would be extremely expensive, but federal assistance is available and increased revenue from business would return the investment.

Chamber of Commerce
Metropolitan Area Local Governments

Oppose A flood wall 30' high would greatly reduce both access to and the view of the river from the downtown area. It would also create a funnel for flood waters causing super-floods in the future because the velocity of the water shooting out at the lower end of the wall will be much greater than normal. The expenditure of $90 million is a poor use of taxpayers money—"You can't fool Mother Nature." Development should not be encouraged in flood plains.

Environmental Concern Group
Recreational Users Group
Farmers' Forum
Taxpayers' Association

POLICY 4 Install and maintain fish ladders on all existing and future dams, so that fish will have free access to all parts of the river.

Neutral

Farmers' Forum
Taxpayers' Association

Favor Anadromous fish are those which live most of their lives in the ocean, but return to fresh water streams to spawn. Shad, herring, striped bass (rockfish) and sturgeon are of this type and they have not been able to migrate up the James for many years because their progress has been blocked by dams. As a result their numbers have decreased dramatically over the years. Building and maintaining fish ladders would encourage them to return to their native habitats. Fish ladders have been required by state law since the late 1800's, but the law has never been enforced.
Environmental Concern Group
Recreational Users Group

Oppose Fish ladders would cost money to install and maintain—an added burden on both industry and government which use the dams for various purposes.
Chamber of Commerce
Metropolitan Area Local Government
State and Federal Agencies

POLICY 5 Clean up the debris and deserted buildings on Belle Isle. Build an environmental education center for use by school groups and interested citizens.

Neutral Belle Isle clean up is a good idea, but would require spending local funds; other issues frequently seem to take precedence over this one.
Farmers' Forum
State and Federal Agencies

Favor With hazardous conditions removed, Belle Isle could be a beautiful recreation site with numerous opportunities for learning about history and the environment in the Richmond area. It would generate interest in the James River and its health and promote Richmond as an attractive place to live and work.
Environmental Concern Group
Recreational Users Group
Chamber of Commerce
Taxpayers' Association

Oppose The cost of trained staff, law enforcement, parking facilities, restrooms, etc. is high and people management problems would increase with more visitors.
Metropolitan Area Local Government

INTEREST GROUPS AND THEIR ACTUAL COUNTERPARTS

A number of agencies and organizations with interests in the James River are listed in the activity called INFORMATION PURSUIT. The seven interest groups for this simulation are listed below with their possible real counterparts. You might consider having one student write or call each group and determine its position regarding each of the five policies. If you decide to have students write letters, please use the guidelines found in the INFORMATION PURSUIT activity (addresses and phone numbers are listed there also).

Chamber of Commerce—Virginia Petroleum Council: Virginia, Maryland, and Delaware Association of Electric Cooperatives

Metropolitan Area Local Governments—Richmond City Council (or the City Manager); and the Boards of Supervisors of Chesterfield, Hanover, Henrico, and Goochland Counties (or the County Administrator in each county) Look in your local phone book for addresses and phone numbers.

Farmers' Forum—Soil Conservation Service; VPI Cooperative Extension Service; Virginia Soil and Water Conservation Commission; Virginia Forestry Association; Virginia Association of Soil and Water Conservation Districts; Virginia Farm Bureau Federation

Environmental Concern Groups—Chesapeake Bay Foundation; Conservation Council of Virginia Foundation; Environmental Defense Fund; Izaak Walton League of Virginia; Lower James River Association; Nature Conservancy; Virginia Chapter of the Sierra Club; Water Pollution Control Federation; City of Richmond James River Park

Recreational Users Group—Virginia Anglers Club; Virginia B.A.S.S. Federation; Coastal Canoeists; Float Fishermen of Virginia; Commission of Game and Inland Fisheries

Taxpayer's Association—local taxpayers (have students talk to their parents and teachers)

State and Federal Agencies — Council on the Environment; Department of Health; Environmental Protection Agency; Virginia Marine Resources Commission; Virginia State Water Control Board; Water Resources Research Center

NOTES TO THE TEACHER

Put a copy of the scoring grid on the board or on a wall chart. At the end of each round, have each interest group *write down* the points it is going to allocate to each policy on a slip of paper and give it to you. Then put all the votes on the grid *at once* (If you write some down while other groups are still deciding, they will use the scores of the early birds to make their decisions for that round!)

Remind the students that a policy must have a cumulative total of 500 points at the end of the third round in order to pass.

Allow them to vote in the first round without much interference from you. Often groups will spread their 100 points out over several policies and will not try to persuade any other group to vote their way. After the points are totalled up the first time, they should realize that the "scatter" and "isolationist" approach will not succeed in getting any policy passed.

If this realization does not strike them, you might remind them during the second round that they are allowed to talk with other groups and can try to persuade others to vote in their favor.

If the groups never get together and no policy receives 500 points by the end of the third round, discuss with the group why this happened and what they might have done to prevent it.

If one or more policies do receive enough votes to pass, discuss which ones succeeded and why. Often the most important policies are also the most controversial and have the greatest difficulty achieving wide enough acceptance to pass. Use this opportunity to compare this process to actual decision-making that takes place concerning environmental management.

GROUPS	**POLICIES**														
	Round 1					***Round 2***					***Round 3***				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1. Chamber of Commerce															
2. Metropolitan Area Local Governments															
3. Farmers' Forum															
4. Environmental Concerns Group															
5. Recreational User Group															
6. Taxpayers' Association															
7. State and Federal Agencies															
Totals															
Cumulative Totals															
Grand Totals															

SAVE THE RIVER SIMULATION

GRADE LEVEL AND SUBJECT INDEX

TITLE OF ACTIVITY	PAGE	GRADES	SUBJECT
Belle's Profile	60	7, 8, 9	Sci & SS
Crazy Critters	56	4, 5, 6, 7	Sci
Critter Collecting	54	4, 5, 6, 7	Sci
Divide and Conquer	44	4, 6, 9	Sci & SS
Down the Drain	86	4, 5, 6, 7, 8, 9	Sci & SS
Fall Line City	14	4, 5	SS
Flour Power	24	4, 5, 6, 7	SS
Information Pursuit	89	4, 5, 6, 7, 8, 9	Sci & SS
Iron & Industry	34	4, 5, 7, 9	SS
It's a Fact — Or Is It?	43	7, 9	SS
James Goes This Way	46	4, 6, 9	Sci
James' Profile	66	9	Sci & SS
James River Gazette	94	4, 5, 6, 7, 8, 9	Sci & SS
Jamestown on the James	12	4, 5, 9	SS
Kanawha Canal	20	4, 5	SS
Make an Island	64	7, 9	Sci & SS
Nutrients and Water Quality	75	4, 5, 6, 7, 8, 9	Sci & SS
Planters' Advantages	18	4, 5	SS
Plight of the Prisoner	37	7, 8	SS
Poison in the Food Chain	77	4, 6, 7, 8, 9	Sci & SS
Pothole Peeking	68	5, 7, 9	Sci
Rolling Down the River	48	4, 6, 9	Sci
Round and Round and Round It Goes	51	4, 6	Sci
Row Your Boat	28	4, 5, 7	SS
Save That Soil	70	4, 6, 8, 9	Sci & SS
Save the River Simulation	95	6, 7, 8, 9	Sci & SS
Tale of Two Cities	41	5, 7, 9	SS
Temperature and Dissolved Oxygen	72	6, 7, 8	Sci
Test the Waters	82	6, 7, 8	Sci
Toxic Troubles	80	4, 6, 7, 8, 9	Sci & SS
Water We Doing to Our Water	83	4, 5, 6, 8, 9	Sci & SS

Parent involvement activities are shown in bold face.

FACTS AND FIGURES ABOUT THE JAMES RIVER BASIN

Length of James River — approximately 330 miles from confluence of Jackson and Cowpasture Rivers near Iron Gate in Botetourt County to mouth at Hampton Roads

Total length of the river *basin* — 450 miles

Land area of river basin — 10,102 square miles (approximately 25% of the total surface of Virginia)

Counties in basin — all or part of 39 counties

Cities in basin — 18

Population in 1980 — 1,718,945 (approximately one-third of the state's population)

Projected population — year 2000 (2,109,100), year 2030 (2,723,800)

Average annual precipitation — 42.5 inches

Average annual temperature — 57 degrees Fahrenheit

Mean monthly flow at Richmond (1934–1981) in cubic feet per second (cfs) for January: 8,200 February: 10,270 March: 11,510 April: 10,050 May: 6,130 June: 3,660 July: 2,270 August: 1,820 September: 1,350 October: 1,680 November: 3,180 December: 4,610

Seven/day–10/year low flow — 680 cubic feet per second (cfs)

Maximum flow (June 23, 1972) — 313,000 cfs

Most damaging floods — Hurricane Camille, August 1969; Hurricane Agnes, June 1972; Tropical Storm Juan, November 1985

Hurricane Camille damage — 151 killed, 200 miles of highway and 133 bridges damaged, $116 million property damage

Hurricane Agnes damage — highest river level since 1771, $37 million damage in Richmond area alone, 6,000 homes damaged or destroyed

Virginia Water Control Board water quality monitoring stations in basin — 118

1982–83 water withdrawal and use from the basin — 3,200,000,000 gallons per day (8 times greater than for any other river basin in the state)

Major industries — transportation, lumbering, manufacture of chemicals, furniture, textiles, and apparel

Ports — Richmond and Hopewell

James River restricted to commercial fishing due to Kepone contamination — 113 miles

Major tributaries of James River — Jackson, Cowpasture, Maury, Tye, Rivanna, Appomattox, Chickahominy, Nansemond, and Elizabeth Rivers

The James River below the city of Richmond is an estuary which flows into the Chesapeake Bay

The James is one of the three largest tributaries of the Chesapeake Bay (along with the Potomac and the Susquehanna)

Information taken from the following sources:

Chesapeake Bay Program: Findings and Recommendations United States Environmental Protection Agency, Region 3, Sixth and Walnut Streets, Philadelphia, PA 19106, September 1983

Hydrologic Unit Populations for Virginia, 1980 with Projections for 1990, 2000, 2010, 2020, and 2030 Commonwealth of Virginia, Virginia State Water Control Board, Basic Data Bulletin #63, July 1984

Joseph G. Loesch, Steven M. Atran, William H. Kriete, Jr., and Ben Rizzo *Feasibility Study of Fish Passage Facilities in the James River, Richmond, Virginia: Final Report* Virginia Commission of Game and Inland Fisheries and Virginia Institute of Marine Science, December 1983

Kathryn P. Sevebeck, Jacob H. Kahn, and Nancy L. Chapman, *Virginia's Waters* Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1986

Virginia Water Quality Assessment 1986, Volume Two of Two: Information Bulletin 565, April 1986; Virginia Water Control Board 305(b) Report to EPA and Congress for the period July 1, 1983 to June 30, 1985

Virginia Water Withdrawal and Use Report for 1982 & 1983 Basic Data Bulletin 64, July 1985, Virginia Water Control Board

GLOSSARY

Absorb—to soak up or drink in a liquid.

Acid rain—precipitation in any form (rain, snow, sleet, hail, fog) that has a pH lower than normal. Precipitation is generally considered to be acid when the pH is 5.6 or lower.

Adaptation—the changes that take place in the behavior or the structure of an organism. Adaptations allow an organism to adjust to a new condition or environment so that it has a better chance of survival.

Adsorb—to collect a gas, liquid, or dissolved substance in condensed form on a surface, as charcoal adsorbs a gas.

Algal bloom—excessive growth of aquatic algae. The condition occurs when increased amounts of nutrients such as nitrogen and phosphorus are added to the environment.

Alluvium—sediment deposited by streams in comparatively recent times.

Archaeologist—a specialist in the scientific study of the life and culture of historic or ancient people by analysis of their artifacts, inscriptions, monuments, and other such remains.

Barge—a large flat-bottomed freight boat used on inland waters.

Bateau(x)—a double-ended, flat bottomed rowboat used on rivers. These boats were used extensively on the James River and Kanawha Canal for carrying goods to market.

Camouflage—a disguise or false appearance that is used to hide from something. The spots on the back of a fawn help it match the light and dark patches in the woods as sun comes through the trees. When the fawn lies very still it is difficult to see.

Canal—an artificial waterway dug across land. The James River and Kanawha Canal was constructed to traverse unnavigable sections of the James River.

Coliform bacteria—any of several bacilli, especially of the genera *Escherichia*, found in the intestines of man and animals. Its presence in water indicates fecal pollution.

Contour interval—the difference in elevation between two adjacent contour lines on a topographic map.

Contour lines—lines on a topographic map joining all points of equal elevation on a part of the earth's surface.

Contour plowing—plowing horizontally along the contour lines of the land in order to reduce erosion.

Controlled variable—all the variables which are held constant or kept the same throughout a scientific experiment.

Digester bacteria—the layer of bacteria, molds, worms, larvae, and other organisms in a water treatment plant which digest many of the pollutants in sewage. This is part of the secondary treatment process.

Dissolved Oxygen—the oxygen content of water. Fast-moving, swirling water has greater contact with the air, thus increasing the oxygen content of the water. Cold water can hold greater amounts of oxygen than can warm water.

Divide—the geographic line or zone of higher ground between two streams or drainage basins which are side by side.

Ecosystem—a natural unit of living and non-living things. Materials are exchanged back and forth between the living and non-living components.

Erosion—the wearing away of the earth's surface, as by floods, glaciers, waves, wind, or any natural process.

Eutrophication—an abundant accumulation of nutrients in an aquatic system that supports a dense growth of plant and animal life, the decay of which depletes the waters of oxygen.

Fall line or Zone—a geographic line, marked by waterfalls and rapids, where rivers descend abruptly from an upland to a lowland (as in the Piedmont and the Coastal Plain.

Ferrier—a man who owns or operates a ferry. A ferry is a commercial boat for conveying passengers and goods over streams and other bodies of water.

Gradient—the degree of slope in a road, riverbed, etc.

Granite—a very hard, igneous rock, composed of quartz, feldspar, and mica, or at least two of these minerals, crystallized together, varying greatly in textures and color.

Habitat—the natural home or dwelling place of a plant or animal.

Herbicide—pesticide designed to kill specific plants.

Hogshead—a large barrel or cask, especially one containing from 100 to 140 gallons. Hogshead containers were used to transport crops and other goods to market.

Hydraulic—water which is churning with tremendous force in a vertical direction, especially at the base of dams or large rocks.

Immature river—one which has V-shaped valleys, rapids and waterfalls which have not yet been flattened by years of erosion. It generally carries a small volume of water and has few tributaries.

Immigrant—a person who comes to live in a country in which he or she was not born.

Insecticide—pesticide designed to kill specific insects.

Iron furnace—a large cylinder lined with heat-resistant brick used in the processing of iron from its ore. The ore is mixed with limestone (to help remove impurities) and coke (a processed form of coal) and heated to extreme temperatures. As the coke burns, it changes iron oxide in the ore to pure iron and melts the iron and the impurities. Molten iron is "tapped" off the bottom of the furnace. "Recipe" for iron—To make 1 ton of iron—use 1 3/4 tons iron ore, 3/4 ton coke, 1/4 ton limestone.

and 4 tons of air.

Manipulated variable—the ONE variable which is changed during a scientific experiment.

Mature river — one which has well-established tributaries and carries its largest volume of water at this stage. The main erosion takes place on the sides of the valley walls rather than on the bottom of the channel. Thus it tends to have a wider U-shaped valley as opposed to its youthful V-shaped valley.

Meander — long winding curve in a well-developed river.

Non-point pollution—pollution which enters a stream or river from a wide area. It is often the result of too much lawn or farm fertilizer, automobile oil, soil from farms or construction sites, etc.

Oxbow lake—a lake which is formed when sediment in a river is deposited, completely blocking a meander.

Packet boat—a boat that travels a regular route carrying passengers, freight, and mail; usually pulled by mules.

Persistent—continuing to exist or endure; as in a persistent pesticide which is not easily broken down into basic elements.

Pesticide—a general term referring to chemicals used to control unwanted organisms, either plant or animal.

pH—a symbol for the degree of acidity or alkalinity of a solution. The value for pure distilled water is neutral or pH 7. pH values from 0 to 7 are acid, and from 7 to 14 are alkaline or base (basic). The scale is a logarithmic one so a solution which has a pH of 5 is 10 times more acid than one with a pH of 6 and 100 times more acid than one with a pH of 7.

Phosphates—salts or esters of phosphoric acid found in laundry and dishwashing detergent and fertilizer.

Phosphorus—a non-metallic chemical element. Its compounds are used in making fertilizers and it is a necessary component in plant and animal life (bones, nerves, etc.).

Phytoplankton—microscopic plants in a body of water.

Plankton—the microscopic plant and animal life found floating or drifting in bodies of water. It is used as food by other organisms.

Planter (plantation owner)—a person who owns or manages a large estate or farm on which one main crop, such as cotton, tobacco, or coffee is cultivated, usually by resident laborers.

Point source pollution—pollution which enters a stream or river from a single place such as a discharge pipe.

Pothole—a deep, round basin worn in the rocks or rockbed of a stream by the grinding action of sand or pebbles caught in natural fissures and whirled around by the water.

ppb (parts per billion)—a term used to describe how much of a contaminant is present in air or water. A reading of 7 ppb would mean there were 7 parts of the pollutant in 1 billion parts of air or water. (See the activity called TOXIC TROUBLES for a graphic description of ppb and ppm.)

114

ppm (parts per million)—a term used to describe how much of a contaminant is present in air or water. A reading of 7 ppm would mean there were 7 parts of the pollutant in 1 million parts of air or water. (See activity called TOXIC TROUBLES for a graphic description of ppb and ppm.)

Predator—an animal which lives by hunting other animals for food.

Primary treatment—the first phase of wastewater treatment. The sewage stands in large tanks for a time and the solids sink to the bottom and are removed. This phase removes about 35% of all pollutants.

Profile—a line representation of various elevations of an area of land so that it appears as it would if you were standing beside it.

Quarry — a place where stone is excavated, as by cutting or blasting, for building purposes. It is usually open to light, and in this respect differs from a mine.

Responding variable—the variable which changes as a result of the changing manipulated variable in a scientific experiment.

SAV (Submerged Aquatic Vegetation)—completely submerged rooted aquatic plants. These plants bind the loose bottom sediment into a firmer substrate, provide food, organic matter, and living space for aquatic organisms.

Secondary treatment—the second stage of wastewater treatment. Generally this involves either a "trickling filter" or "activated sludge" and it removes about 85% of the pollutants which remain after primary treatment. During the trickling filter process, the wastewater is sprayed over the top of the filter by arms that rotate like a lawn sprinkler. The wastewater then trickles down through a bed of rock and gravel, which is covered with a layer of bacteria, molds, larvae, and other organisms. These organisms simply digest the pollutants remaining in the wastewater. Some treatment plants use the activated sludge process. Wastewater is bubbled by aeration to keep the oxygen level high. This allows microorganisms in the bubbling water to reproduce rapidly and decompose the wastes.

Sediment—the mineral or organic particles carried by a stream or river.

Slag—the fused refuse matter separated during the reduction of a metal from its ore (the impurities that float to the top of melted iron ore).

Stagnant—stale or foul from lack of movement; without motion or current; not flowing or moving as in a stagnant pool of water.

Tertiary (or advanced) treatment — a third phase of wastewater treatment. This is needed for very polluted water from big cities and manufacturing plants or when the treated wastewater is sent to streams with high water quality standards. This type of treatment can remove most of the nitrogen, phosphorus, heavy metals, and other substances that cannot be digested by the microorganisms in the secondary treatment process. It is expensive and very few treatment plants use tertiary treatment

Tidewater—water affected by the flow and ebb of the tide.

Topographic map—a map showing the surface features and some man-made structures of a region (hills, valleys, rivers, lakes, canals, bridges, etc.).

Turbidity—the state of having the sediment stirred up; muddy; cloudy. Turbidity in water is often measured using a secchi disc—a black and white or all white disc which is attached to a rope and lowered into the water until it is no longer visible. The amount of turbidity is determined by how far down the disc can go before it disappears.

Water wheel—a wheel that is turned by the weight or pressure of water falling on it. In the past water wheels were often used to provide power for turning the grinding stone at a grist mill.

Watershed—the region or area drained by a river, stream, etc. It includes all of the land whose rainfall runs into the river either directly or indirectly through the tributaries of the river.

Xenolith—an inclusion in an igneous rock which is mineralogically different from the igneous rock.

Zooplankton—microscopic animals in a body of water.

TOPIC INDEX

The following is an alphabetical listing of topics included in this project. It is not a comprehensive listing; that is, it does not list every possible topic that is covered in the activities. It does include topics that might be discussed in grades 4–9 in science and social studies classes.

Activities under each topic are listed alphabetically, not according to the degree to which they emphasize the topic.

ADAPTATIONS
Crazy Critters, Critter Collecting, Pothole Peeking

AGENCIES
Down the Drain, Information Pursuit, James River Gazette, Save the River Simulation, Water We Doing to Our Water?

BELLE ISLE
Belle's Profile, Make an Island, Plight of the Prisoner

BOATS
Flour Power, Kanawha Canal, Row Your Boat

CANALS
Fall Line City, Flour Power, Kanawha Canal, Row Your Boat, Tale of Two Cities

CHESAPEAKE BAY
Crazy Critters, Divide and Conquer, Down the Drain, Information Pursuit, James River Gazette, The James Goes This Way, James River Profile, Jamestown on the James, Nutrients and Water Quality, Poison in the Food Chain, Rolling Down the River, Round and Round and Round It Goes, Save That Soil, Save the River Simulation, Temperature and Dissolved Oxygen, Test the Waters, Toxic Spill, Water We Doing to Our Water?

CIVIL WAR
Make an Island, Plight of the Prisoner

COLONIAL LIFE
Fall Line City, Jamestown on the James, Kanawha Canal, Planters Advantages, Row Your Boat

CONSERVATION
Down the Drain, Save That Soil, Water We Doing to Our Water?

ECOSYSTEM
Critter Collecting, Crazy Critters, Nutrients and Water Quality, Poison in the Food Chain, Temperature and Dissolved Oxygen, Test the Waters, Toxic Troubles.

ENRICHMENT (NUTRIENT)
Nutrients and Water Quality, Down the Drain, Temperature and Dissolved Oxygen

ENVIRONMENTAL QUALITY
Critter Collecting, Information Pursuit, James River Gazette, Jamestown on the James, Nutrients and Water Quality, Poison in the Food Chain, Pothole Peeking, Round and Round and Round It Goes, Save the River Simulation, Temperature and Dissolved Oxygen, Test the Waters, Toxic Troubles

EROSION
The James Goes This Way, James' Profile, Nutrients and Water Quality, Save That Soil

FALL LINE OR FALL ZONE
Fall Line City, Flour Power, Iron and Industry, James' Profile, Kanawha Canal, Make an Island, Planters Advantages

FOOD CHAINS
Crazy Critters, Poison in the Food Chain, Temperature and Dissolved Oxygen

GEOLOGY
Divide and Conquer, The James Goes This Way, James' Profile, Make an Island, Pothole Peeking, Rolling Down the River, Save That Soil, Toxic Troubles

HABITAT
Crazy Critters, Critter Collecting, Pothole Peeking

HISTORICAL ACCURACY
It's a Fact, Plight of the Prisoner

INDUSTRY
Belle's Profile, Fall Line City, Flour Power, Iron and Industry, The James Goes This Way, Row Your Boat

MANAGEMENT (ENVIRONMENTAL)
Information Pursuit, James River Gazette, Poison in the Food Chain, Round and Round and Round It Goes, Save the River Simulation, Test the Water, Toxic Troubles, Water We Doing to Our Water?

ORGANISMS
Crazy Critters, Critter Collecting, Nutrients and Water Quality, Poison in the Food Chain, Pothole Peeking, Temperature and Dissolved Oxygen

ORGANIZATIONS
Information Pursuit, James River Gazette, Save the River Simulation

POLITICAL/ECONOMIC CONCERNS
Divide and Conquer, Down the Drain, Fall Line City, Flour Power, Iron and Industry, James River Gazette, Kanawha Canal, Planters Advantages, Row Your Boat, Save the River Simulation, Water We Doing to Our Water?

POLLUTION
Critter Collecting, Divide and Conquer, Down the Drain, Nutrients and Water Quality, Poison in the Food Chain, Pothole Peeking, Round and Round and Round It Goes, Save That Soil, Save the River Simulation, Test the Waters, Toxic Troubles

POTHOLES
Pothole Peeking, Rolling Down the River

RECREATION
James' Profile, Make an Island, Rolling Down the River, Row Your Boat, Save the River Simulation

SEDIMENTS
The James Goes This Way, James' Profile, Save That Soil

TOPOGRAPHY
Belle's Profile, James' Profile, Make an Island

TOXIC SUBSTANCES
Divide and Conquer, Poison in the Food Chain, Pothole Peeking, Round and Round and Round It Goes, Save the River Simulation, Test the Waters, Toxic Troubles, Water We Doing to Our Water?

TRANSPORTATION
Fall Line City, Flour Power, Iron and Industry, Kanawha Canal, Planters Advantages, Row Your Boat, Tale of Two Cities.

WATER CYCLE
Round and Round and Round It Goes, Divide and Conquer

WATER POWER
Belle's Profile, Fall Line City, Flour Power, Iron and Industry, The James Goes This Way, James' Profile, Make an Island

WATER SUPPLY
Information Pursuit, Jamestown on the James, Round and Round and Round It Goes, Water We Doing to Our Water?

WATER TREATMENT
Down the Drain, Nutrients and Water Quality, Water We Doing to Our Water?

WATERSHED
Divide and Conquer, The James Goes This Way

KIT LIST

The following is a list of the books and non-consumable supplies which are included in the kits accompanying these materials. There are several of these kits located in the Central Office of each of the following school divisions: Chesterfield, Goochland, Hanover, and Henrico, and Richmond City. Check with the Science and/or Social Studies Supervisor or the Director of Instruction in the school division office to request these materials on a loan basis.

There are also several kits housed at the Mathematics and Science Center for the use of private schools in the Richmond area.

Each kit contains the following supplies:

1 *Field Manual for Water Quality Monitoring* — Mitchell and Stapp

6 Pond Life Guides — Reid

1 Secchi Disk

2 Dip Nets

10 Thermometers — −4° to 230° Fahrenheit (−20° to 110° Celsius)

24 Hand Lenses — 2¾" × 1" with 4X and 8X magnification

25 Magnifier Boxes — 1" × 1" × ¾" acrylic hollow cubes with removable magnifying tops (4 × magnification)

Pieces of slag from Belle Isle — artifacts from Old Dominion Iron and Steel Works

Slides and written script

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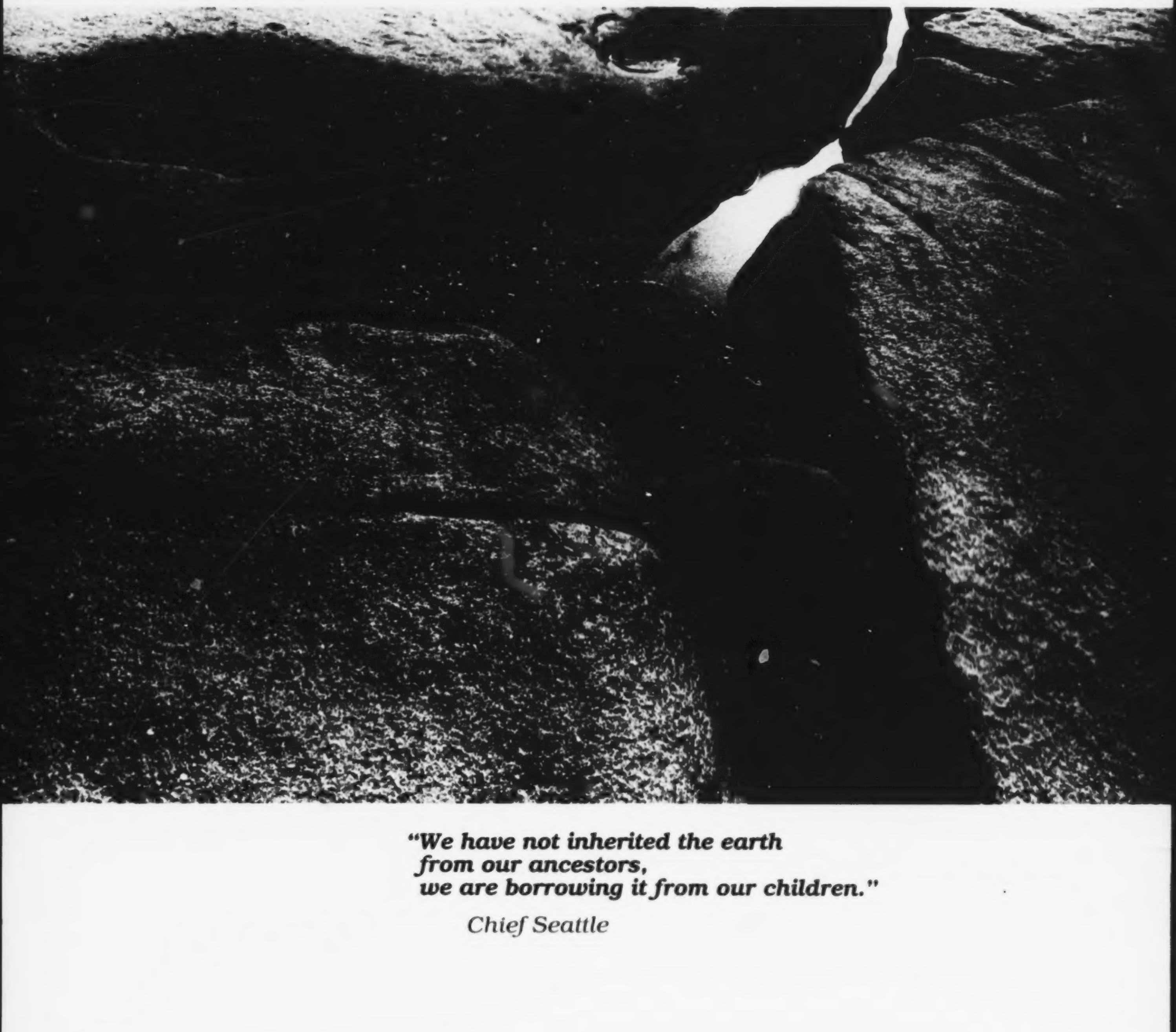
PHOTO CREDITS

Norbert Hamm, pages 2, 10, 15, 18, 19, 30, 35, 36, 40, 64, 41, 49, 50, 51, 54, 68, 77, 87, 90, 91, 95, 96, 112.
Valentine Museum, pages 9, 20, 21, 22, 26, 31, 34, 39, 60.
City of Richmond, City Planner's Office, page 25 and fold out map.
Meghan Hamm, page 28.
Virginia State Library, page 38.



"We have not inherited the earth
from our ancestors,
we are borrowing it from our children."

Chief Seattle